Dar-es-Salaam demonstration test of IMS 1600 Integrated Upper Air System
Dar/es/Salaam, Tanzania, 18-30 October 2004

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1. Introduction

This test was performed to demonstrate that:

(1) The InterMet IMS 1600 Integrated Upper Air System was able to measure winds to a satisfactory operational accuracy

(2) Temperature and humidity measurements from Sippican and Modem radiosondes were of the quality expected from these radiosondes.

It was also intended as an opportunity for the staff from Tanzania to work with staff from the UK and USA to develop their upper air observation skills.

International Met Systems staff that aided in the demonstration were F. Clowney, S. Skibinski, S. Pedersen, S. Wentzel and C. Leroux.

Tanzania Meteorological Agency staff supporting the demonstration included M.R. Mtitu, Dan Jones, Lemmy Mganga, Samwel Mbuya, Sedrick Ndonde, Habiba Mtongori.

2. Modification of test Programme

When the test team arrived at Dar-es-Salaam, the InterMet 1500 radiotheodolite was unable to track. No radiosonde ascent had been archived after 5 October. This failure had occurred within 2 weeks of regular balloon launches beginning at the airport on 27 September 2004. InterMet statistics show that about 15 per cent of the radiotheodolite systems suffer failures during the initial break-in period. The usual Mean Time Between Failure is estimated as 1500 hours in operation.

Tanzanian staff were not confident about what they had to do to prepare balloons and launch them. The position of the radiotheodolite on top of the observation building made it difficult to obtain automatic lock if the balloon was launched from a location close to the balloon shed. In regular operational practice, the balloon needed to be launched from close to the balloon shed.

In most previous installations, InterMet had replaced existing radiotheodolites at stations making regular operational measurements. The installation engineers were not experienced in dealing with situations where training in all the basics of radiosonde observing plus all the basics of radiotheodolite operations was required. There had been a gap of more than ten years since the last radiosonde measurement at Dar-es-Salaam. Once the test team recognised that more training in practical upper air observing skills would be of benefit to TMA staff the test schedules were revised, with many more individual radiosonde launches than originally proposed.

The IMS-1500 was eventually repaired on Friday 22 October. Additional training in radiotheodolite operations took place in the mornings from Monday to Wednesday in the second week and subsequent observations were then performed solely by Tanzanian staff.

The efforts of TMA staff to resolve problems in shipping equipment and radiosonde consumables through the customs were greatly appreciated.

3. Test procedures

Thus, the actual demonstration test consisted of:
14 individual Vaisala RS92 flights, used to train TMA staff in procedures.
8 individual Sippican MKII training flights.

2 nighttime simultaneous comparisons between Sippican and Vaisala,
5 daytime simultaneous comparisons between Sippican and Vaisala,
2 nighttime simultaneous comparisons between MODEM and Vaisala,
2 daytime simultaneous comparisons between MODEM and Vaisala.

The nighttime measurements were usually launched as the sun was setting, so the end of the flights was in the dark.

The radiosondes in the twin flights were suspended at each end of a length of plastic water pipe. See Fig.1.

Fig.1 Preparing to launch a Sippican / Vaisala RS92 twin flight, Dar-es-Salaam.

The balloons used for the testing were a mixture of Pawan and Totex 350g balloons with burst heights typically between 19 and 23 km respectively. Six Totex 1200g balloons lifted radiosondes to heights above 30 km. The 1200g balloons were a little large for the balloon shed. However, the hydrogen generator was easily able to supply sufficient gas for this type of balloon. The large balloons performed best in the nighttime flights.

Data from the Vaisala RS92 radiosondes were received with an Omni-directional antenna, and processed [together with data from a local GPS antenna] using DigiCora III hardware and software in a laptop PC. On some flights the data reception at high elevations and longer ranges was not always of highest quality, and Vaisala data from the twin flights was discarded when there was little valid raw data. The data display on DigiCora III indicates when data was being interpolated and not a valid measurement.

The number of simultaneous flights was relatively small, but in practice sufficient to identify the main problems with the observations.

4 <u>Evaluation of wind measurements</u>

4.1 Individual wind measurements from Vaisala RS92 GPS system

In the tropics winds do not usually change very rapidly with time, so that measurements about 2 to 3 hours apart are usually in close agreement, see plots of orthogonal wind components in Figs. 2(a) to (d). The variation in the vertical of the GPS wind results from Dar-es-Salaam are consistent with a GPS system that is working correctly, i.e. there are no obvious spikes in the winds which occur when the system malfunctions. Thus, it is expected that the accuracy [1 s.d.] of the wind components is around 0.3 ms^{-1} or better apart from those periods where signal to noise was poor and raw data was intermittent.

Note: all these measurements were performed by staff from Tanzania.

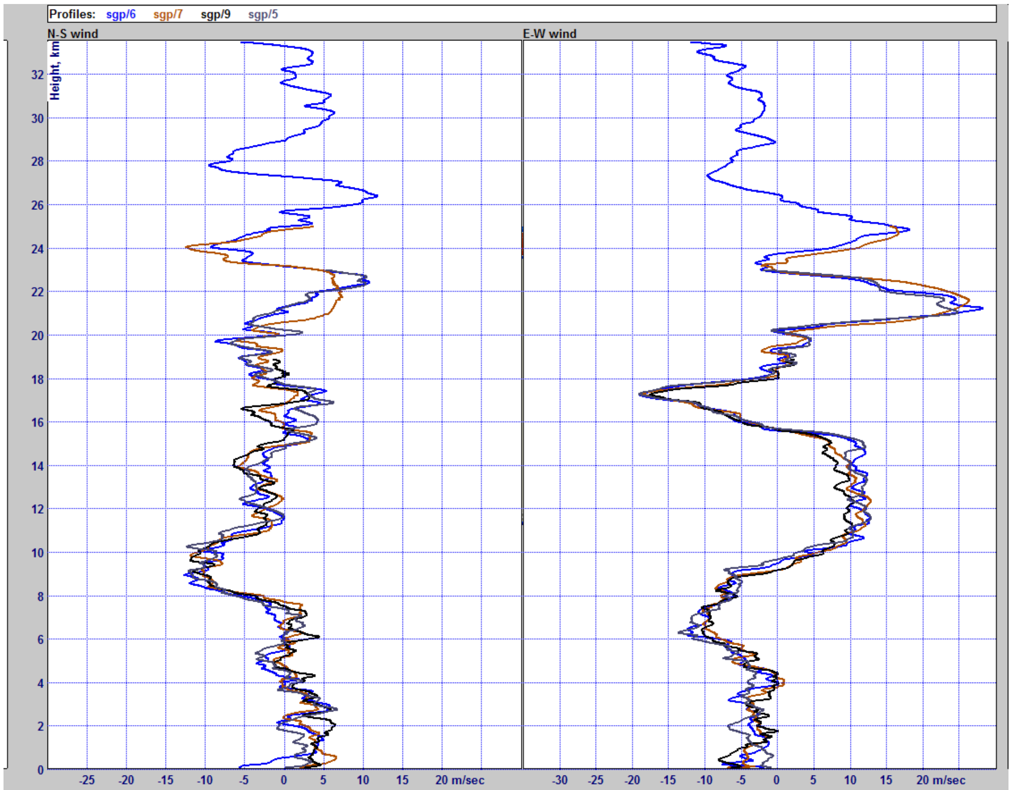

Fig.2 (a) Vaisala wind measurements from 22.10.04 as a function of height.

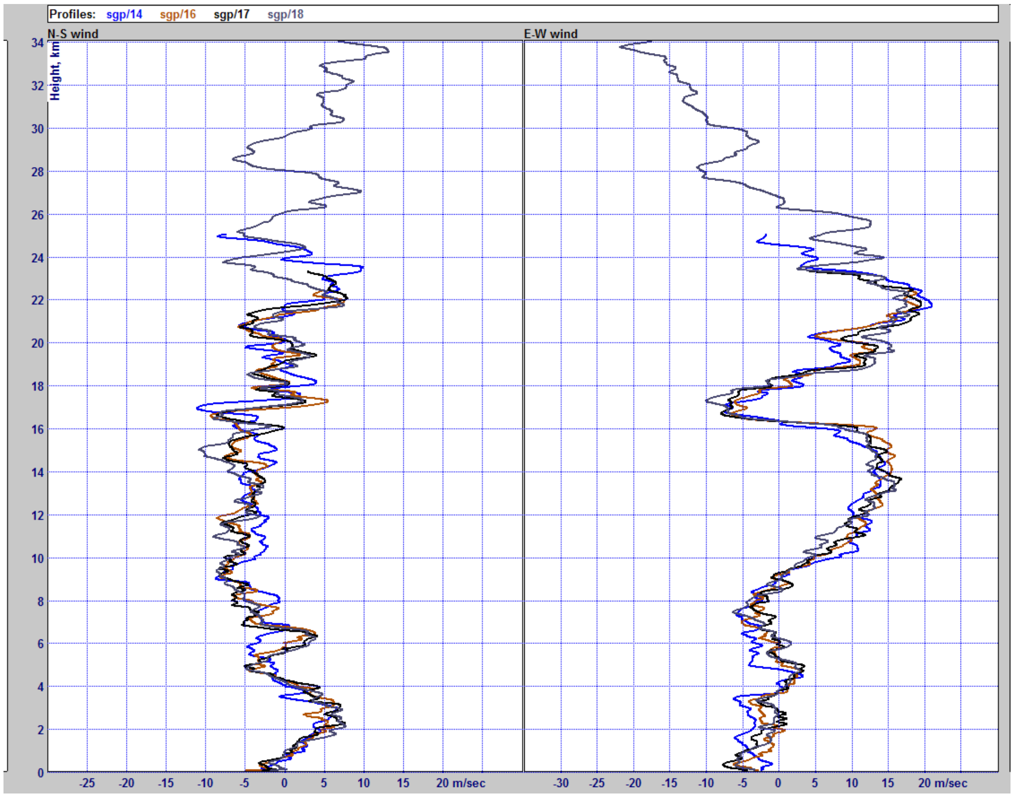

Fig.2 (b) Vaisala wind measurements from 25.10.04 as a function of height.

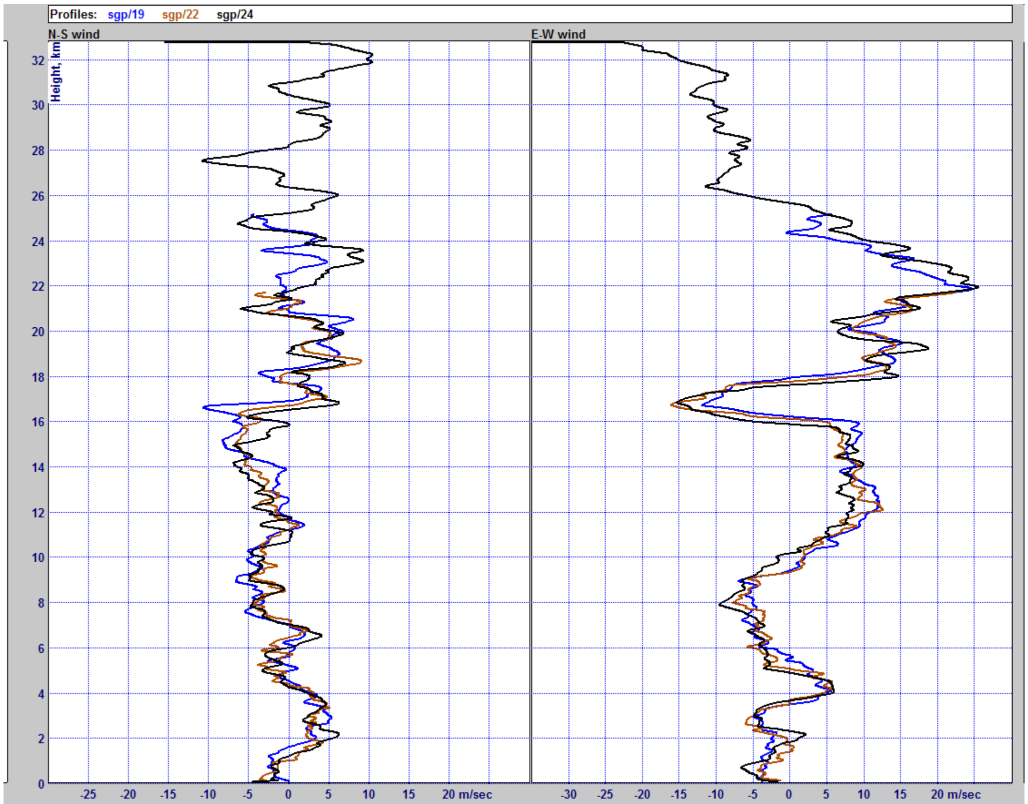

Fig.2(c) Vaisala wind measurements from 26.10.04 as a function of height.

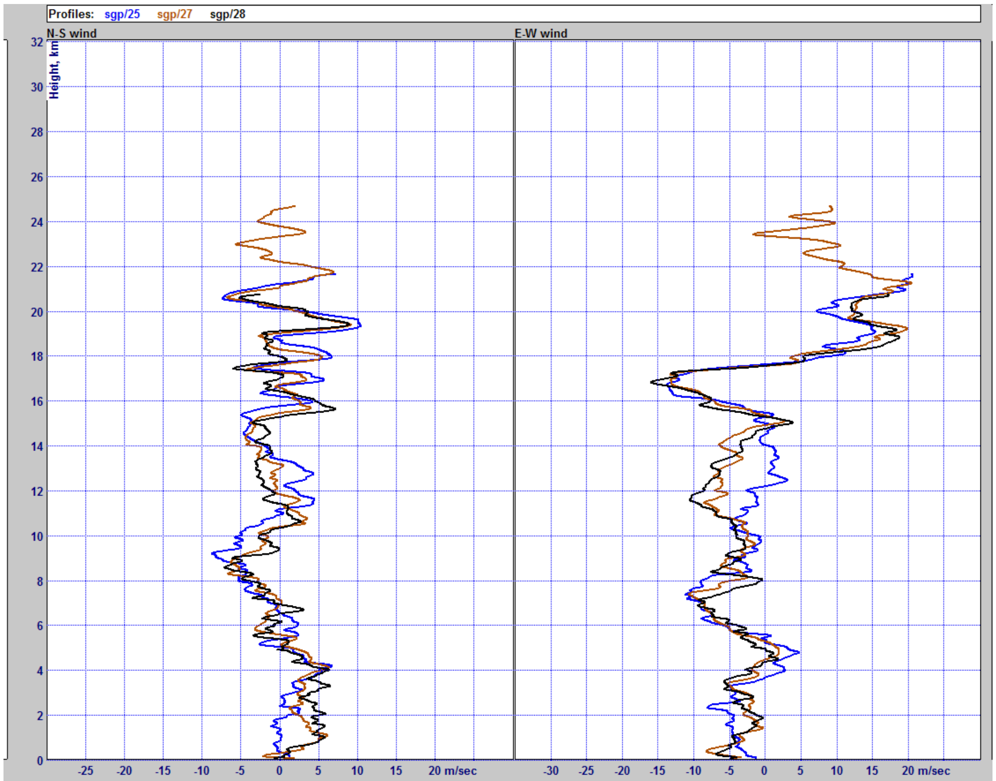

Fig.2 (d) Vaisala wind measurements from 27.10.04 as a function of height

4.2 Individual wind measurements from InterMet 1500 radiotheodolite

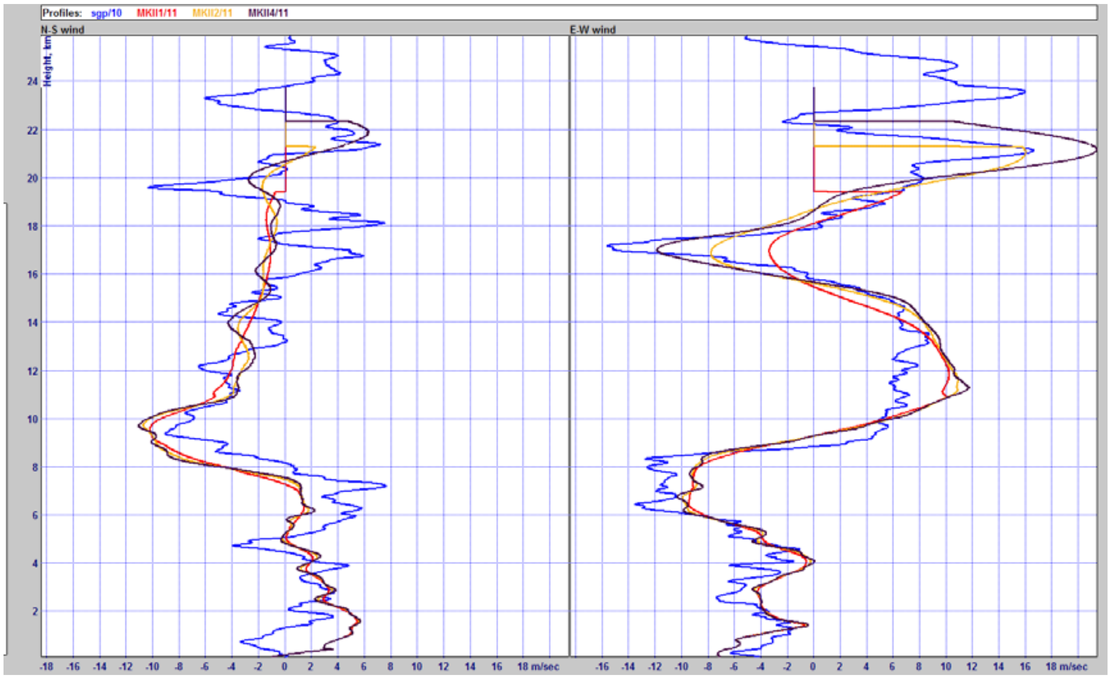

Fig.3 Winds from IMS 1500 computed at 3 different time resolutions compared with a Vaisala RS92 measurement launched about 15 minutes earlier on 23.10.04. The blue curve is the Vaisala measurement.

Fig.3 shows winds from one of the first InterMet radiotheodolite measurements in this test compared with an individual Vaisala measurement launched 15 minutes earlier. The InterMet winds were computed for three different wind time factors, 1 minute [MKII4], 2 minute [MKII2] and [MKII1] 4 minute. These were compared with a Vaisala RS92 measurement launched about 15 minutes earlier. The IMS measurements from 0 to 10 km do not seem to depend on the wind time factor of the computation, but the lower wind time factor clearly improved measurement of the westerly maximum at about 17 km.

The IMS calculation at 4 minutes resolution stopped reporting winds more than 4 km before the end of the flight, and even the 1 minute resolution data finished 1.5 km before the end of the flight. This should not happen with winds of this temporal resolution. In general, the IMS wind measurements appear oversmoothed apparently using data well outside the expected computation window, particularly above 10 km. 1 minute winds ought to have a vertical resolution of around 300m.

All subsequent radiotheodolite wind measurements in the Dar-es-Salaam test were made with the wind time factor set at 1 minute, as agreed by the IMS engineers on site.

Figs. 4(a) to 4(d) show groups of individual IMS radiotheodolite measurements closely spaced in time displayed as a function of height. These wind measurements are smoother than those from the GPS system, but appear consistent with time.

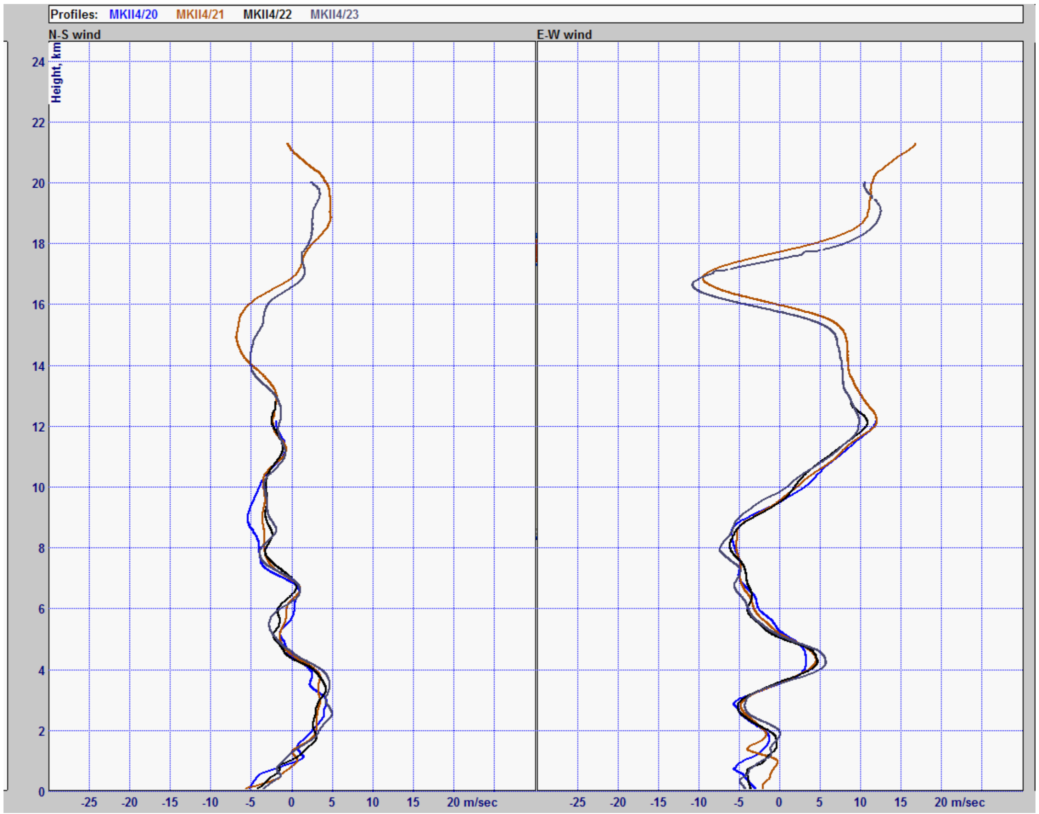

Fig.4 (a) IMS1500 wind measurements from 26.10.04 as a function of height.

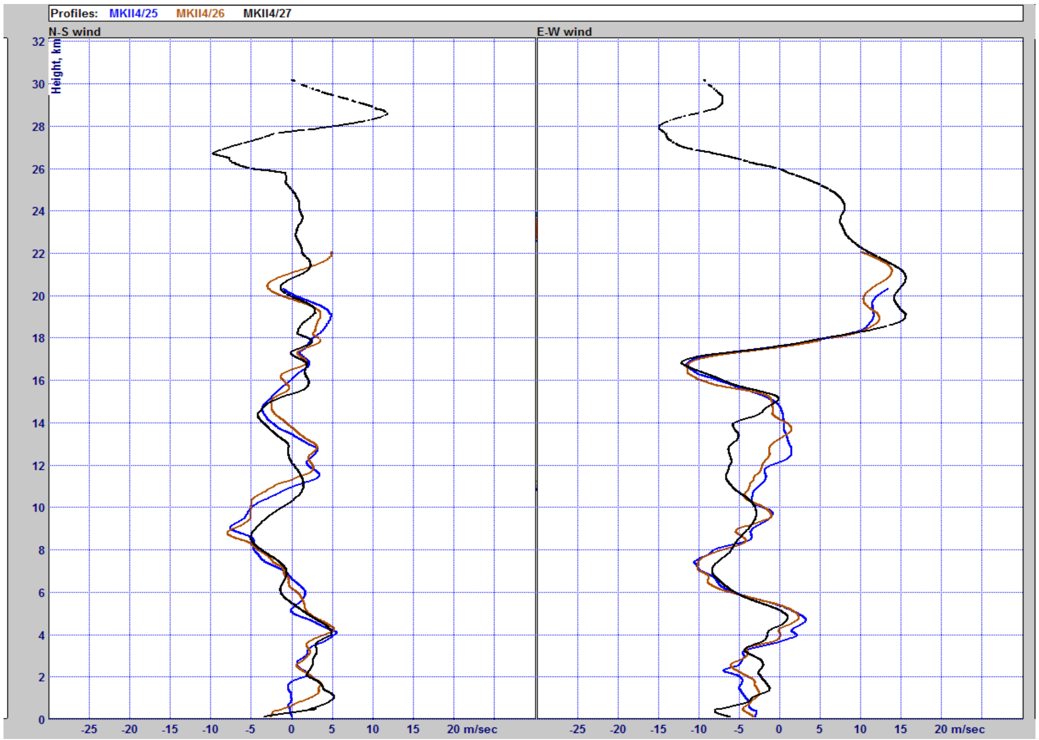

Fig.4 (b) IMS1500 wind measurements from 27.10.04 as a function of height.

In deciding the amount of filtering applied to wind measurements the following should normally be taken into account:

The radiosonde normally swings around under the balloon with a period of between 10 and 15 s depending on the length of the suspension, so this motion needs to be filtered out. Thus, for normal operational ascents with an ascent rate of 5 ms^{-1}, an effective vertical resolution between 150 and 300 m is desirable and would satisfy most users.

Much lower vertical resolution was used in the upper troposphere and lower stratosphere [600m to 1200m] with older operational radiotheodolites in order to reduce the random errors in this type of wind measurement. Wind errors increased very rapidly at low elevations and long range, e.g. see Guide to Meteorological Instruments and Methods of Observation, WMO-No.8 (1996). In Tanzania, the tracking is mostly at high elevations and should allow reliable operation with vertical resolution close to 300m.

A lot of the smaller scale wind structure with vertical wavelengths between 1 and 3 km, e.g. see the wind variations in the N-S wind in Fig 2(d) between 15 and 22 km is caused by the presence of slow-moving gravity waves with large horizontal wavelengths greater than several hundred kilometre.

4.3 Simultaneous comparison between Vaisala RS92 GPS and IMS 1500 winds

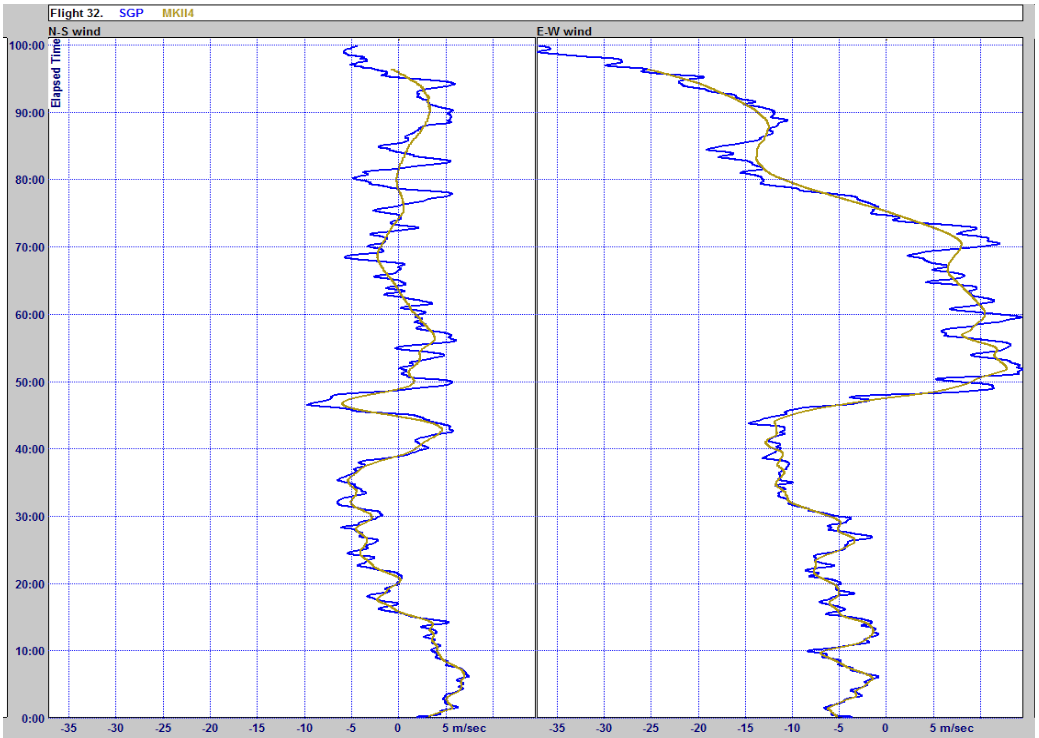

Fig.5 Simultaneous measurements of wind from Vaisala (SGP) and IMS (MKII4) from flight 32 on 28.10.04

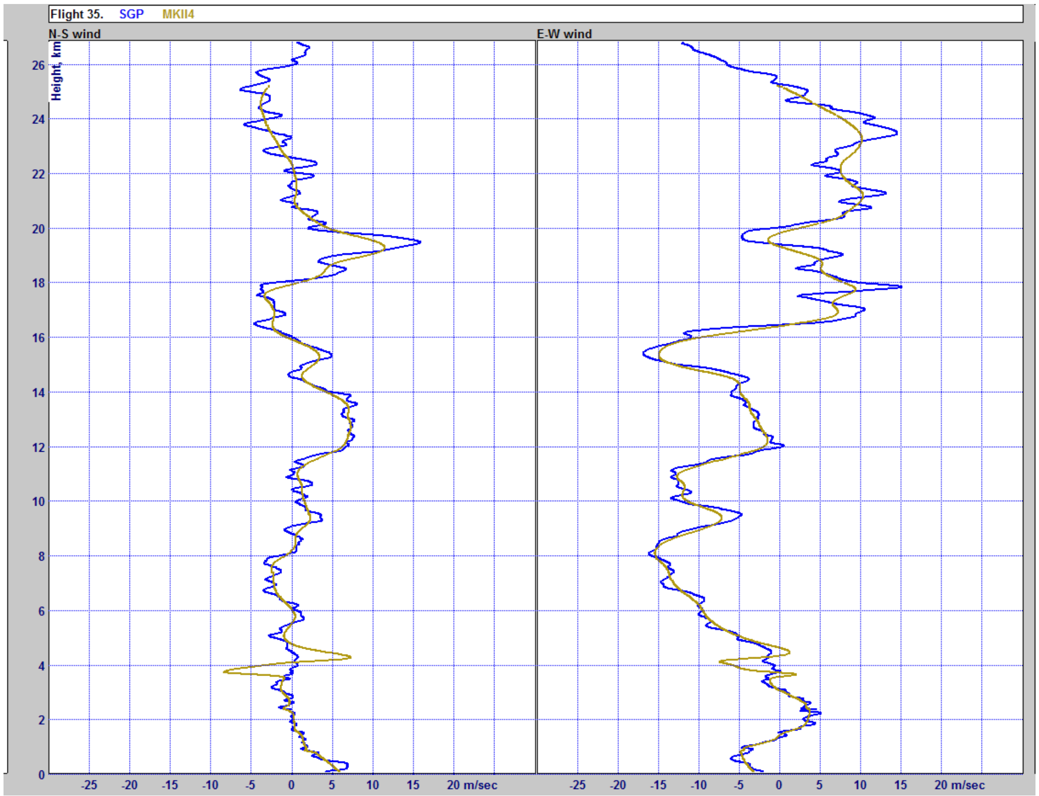

Fig.6 Simultaneous measurements of wind from Vaisala (SGP) and IMS(MKII4) from flight 35 on 29.10.04

In Fig.5, the simultaneous comparison of winds shows good agreement between the two systems for most of a flight reaching heights above 30 km. However, in Flight 35 see Fig.6, there is a significant wind anomaly in the IMS system near 4 km, mostly affecting the N-S wind component. The origin of this problem needs to be investigated. It was not caused by any switch in software or any manual interaction with the tracking antenna.

RMS deviations between simultaneous GPS and IMS winds are plotted as a function of height for 7 twinflight comparisons obtained in Dar-es-Salaam, in Fig.7. These are the RMS differences between all the individual simultaneous samples in the sample within the nominated height band. The anomaly in Flight 35 causes the local maximum in the RMS values for the southerly component near 4 km .

The RMS differences between the two sets of winds indicate that IMS measurements are well within operational requirements from the surface to 14 km. The larger RMS values above this level appear to be a result of too much smoothing of the IMS winds. This smoothing causes error in some of the wind shear structure near the tropopause and also give poor representation of the effects of gravity waves in the lower stratosphere.

Thus. although the IMS 1500 wind measurements could be improved in the stratosphere, the accuracy was acceptable for operational use in the tropics

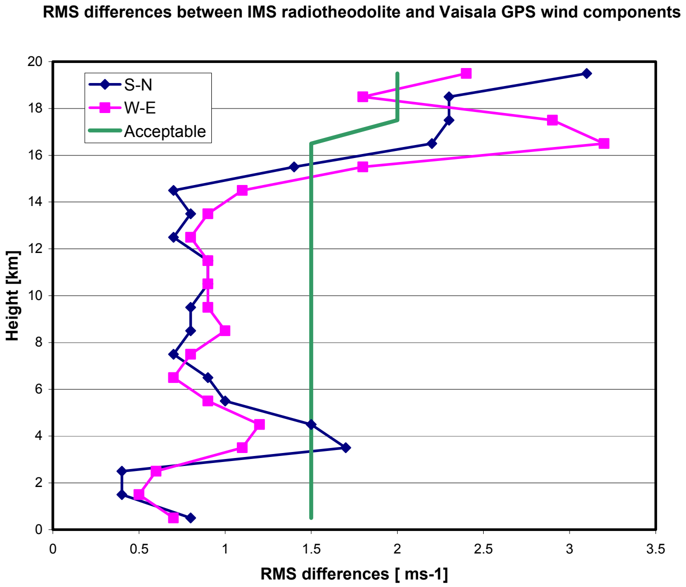

Fig. 7 RMS deviations between Vaisala GPS and IMS southerly and westerly wind components, compared with performance acceptable to UK Met Office requirements.

4.4 Modem GPS winds

The MODEM GL radiosondes were operated with the IMS3014 decoder incorporated in the IMS 1600 system . Comparison against a simultaneous Vaisala RS92 measurement is shown in Fig.8, using standard InterMet processing.

The simultaneous comparison shown in Fig. 8 shows that the IMS algorithm was again oversmoothing GPS measurements. Also the time stamping in the IMS software for the GPS winds was in error by + 1 minute. These two effects caused the errors in the IMS GPS winds to be larger than the IMS radiotheodolite winds, see Fig.9, and to take the westerly component well out of specification near the tropopause. Here the timing in the IMS winds was determined to be in error relative to the IMS MODEM temperature and humidity profiles which were used to synchronise to the Vaisala measurements

When two GPS wind systems are processed correctly with filtering to remove the pendulum oscillations, comparisons between wind components should have RMS deviations of around 0.3 m.s^{-1}. These values would be well within the acceptable limits shown in Fig.9

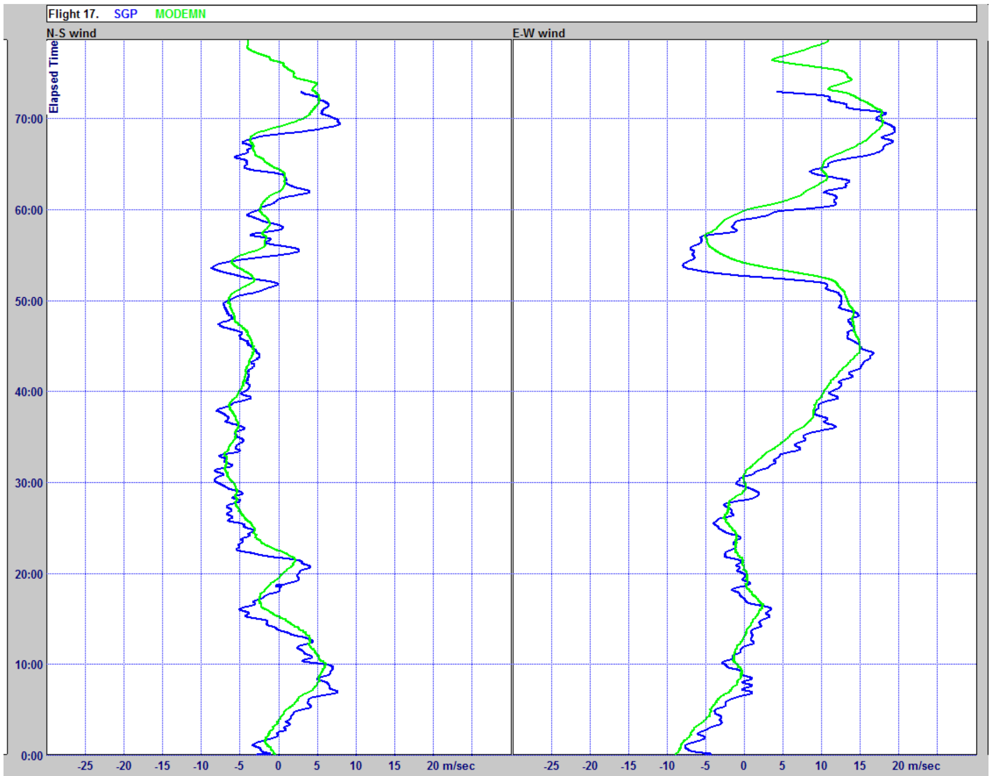

Fig. 8 Simultaneous comparison of GPS wind measurement from Modem GL90 radiosonde, as processed by IMS1600 system and Vaisala RS92 GPS, Flight 17.

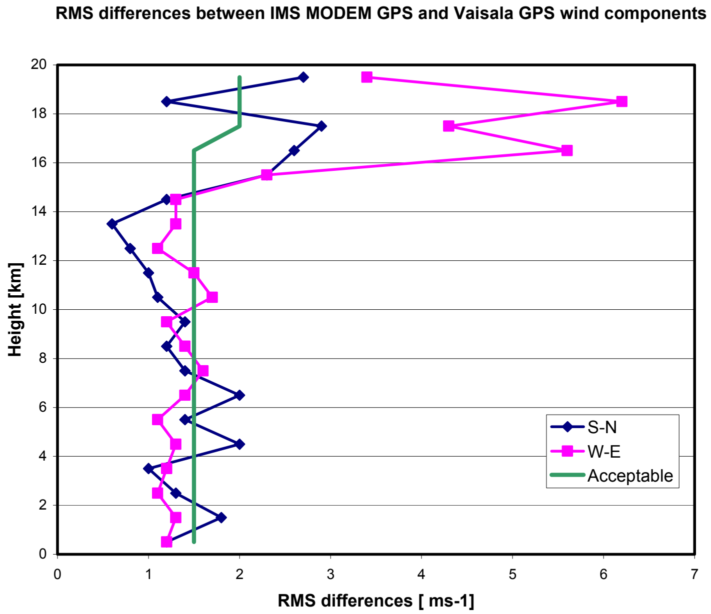

Fig. 9 RMS deviations between Vaisala GPS and IMS MODEM GPS southerly and westerly wind components for 3 flights. compared with performance acceptable to UK Met Office requirements.

In one other flight, the Modem GL90 winds were not processed by the full IMS software , but collected raw. In this case, see Fig. 10, the winds did not have a time offset and the vertical resolution is similar to Vaisala although the pendulum motion of the radiosonde with respect to the balloon needs to be removed.

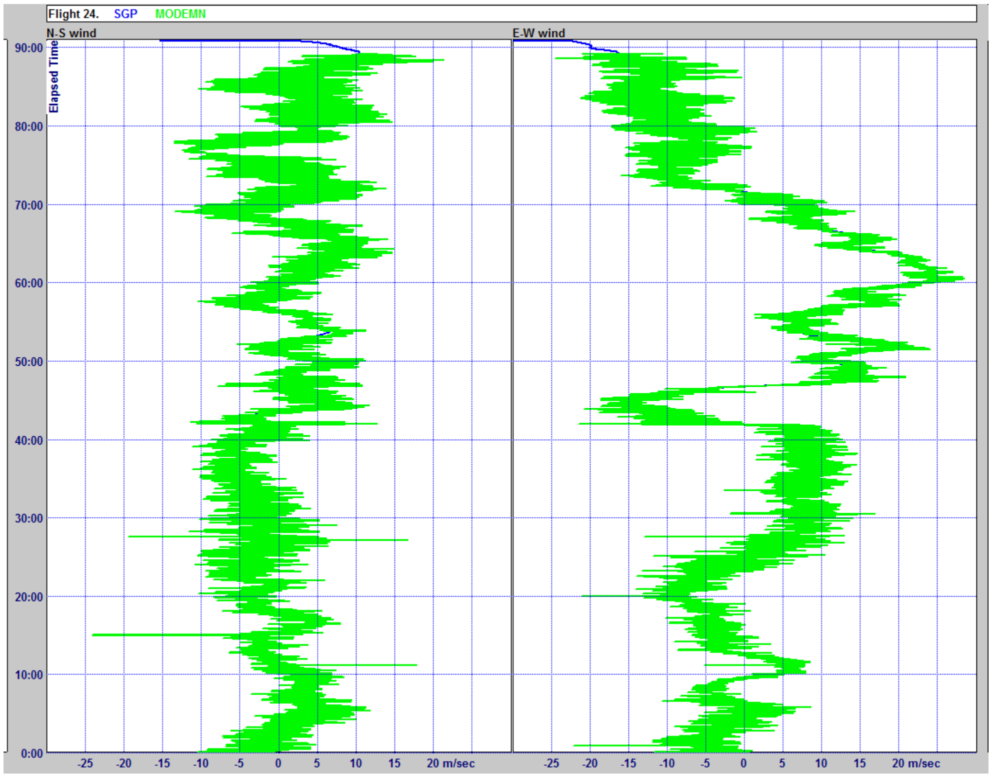

Fig. 10(a)	Simultaneous comparison of GPS wind measurement from Modem GL90 radiosonde, with unprocessed Modem GPS system and Vaisala RS92 GPS, Flight 24

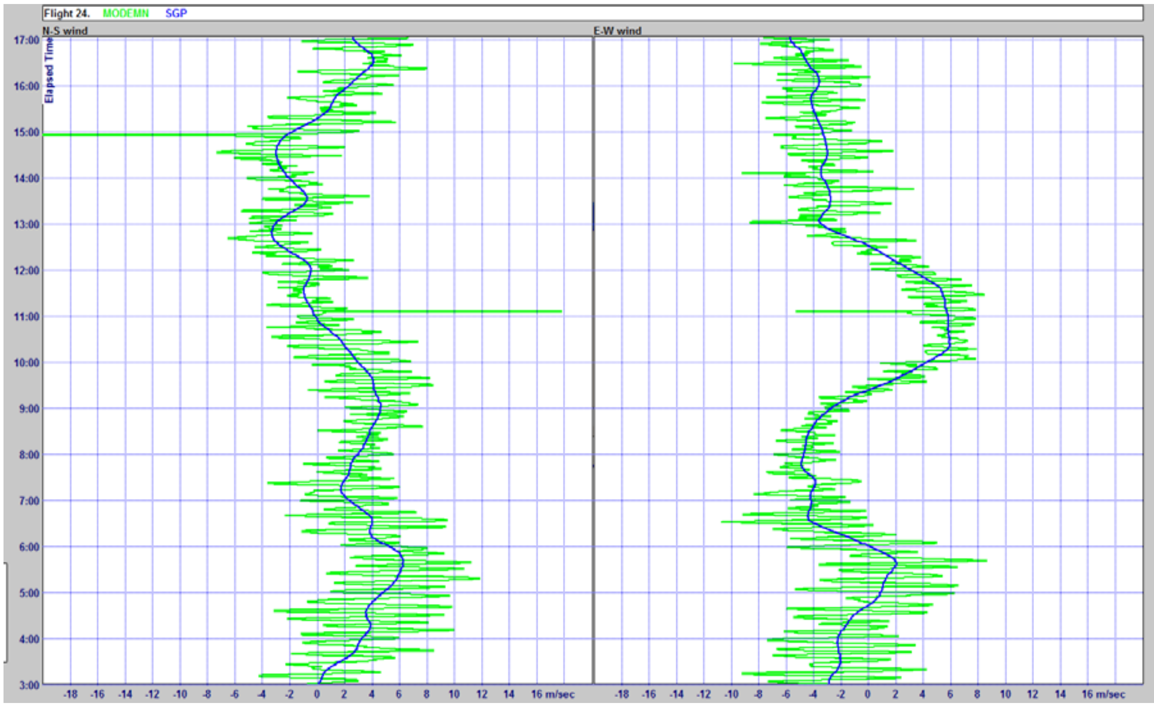

Fig. 10(b) Detail of wind component comparison from Fig.10(a) in the lower troposphere [minutes 3 to 17]

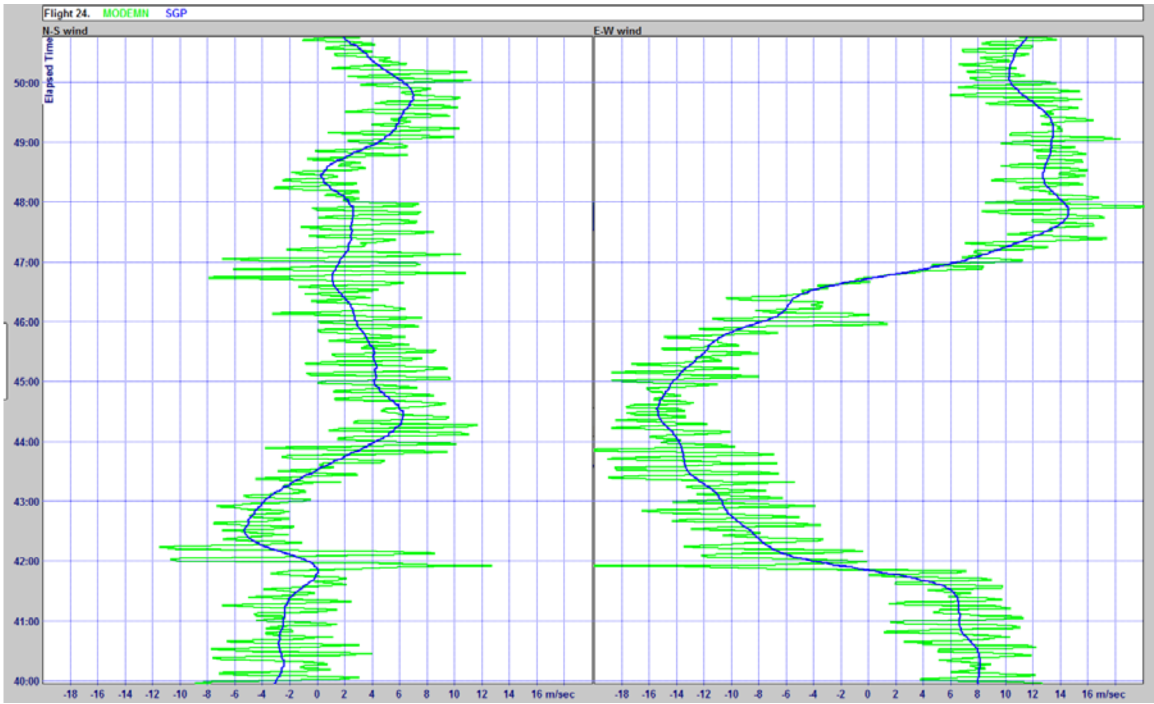

Fig. 10(c) Detail of wind component comparison from Fig.10(a) in the upper troposphere [minutes 40 to 51]

Thus, the GPS winds from the MODEM radiosondes were inherently reliable, but the IMS processing was not sufficiently accurate to retain the inherent accuracy of the original data

5. Evaluation of temperature/ geopotential height measurements

5.1 Introduction

In order to obtain reproducible results from the Sippican MKII radiosonde, Tanzania Met Agency staff were instructed to deploy the temperature sensor outrigger as shown with the chip temperature sensor held above the top of the radiosonde and facing upwards from its support, see Fig.11.

They were also instructed to use the station surface pressure at the start of the radiosonde flight. Sea level pressure had been used in earlier flights before the demonstration test and this led to errors in radiosonde geopotential height..

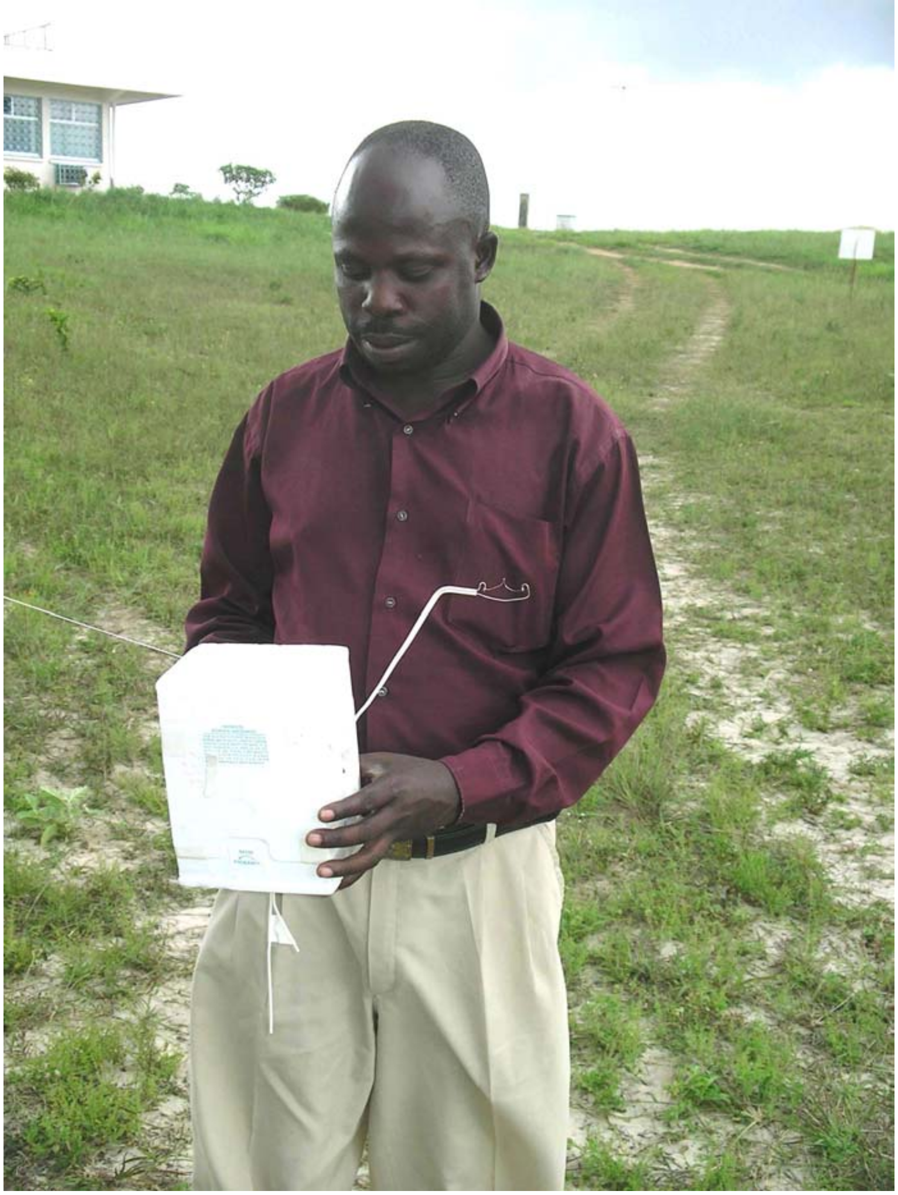

Fig.11 Sippican MKII with chip thermistor deployed ready for launch, with thermistor facing upwards at a height above the top of the radiosonde

5.2 Time series of geopotential height observations

The consistency of the individual radiosonde temperature measurements was monitored by using time series of the 300 hPa height and the [300-100] geopotential height increment, see Fig.11.1(a) and (b). A constant error of 1 degree in temperature at all levels would produce the change in height shown in the figures. The RMS difference of the bias between the Vaisala radiosonde measurements and the polynomial fit at a given time of day was just less than 6 m [1 s.d.], corresponding to a consistency in mean layer temperature measurements of about 0.15 C., both for the surface to 300 hPa and 300 hPa to 100 hPa.

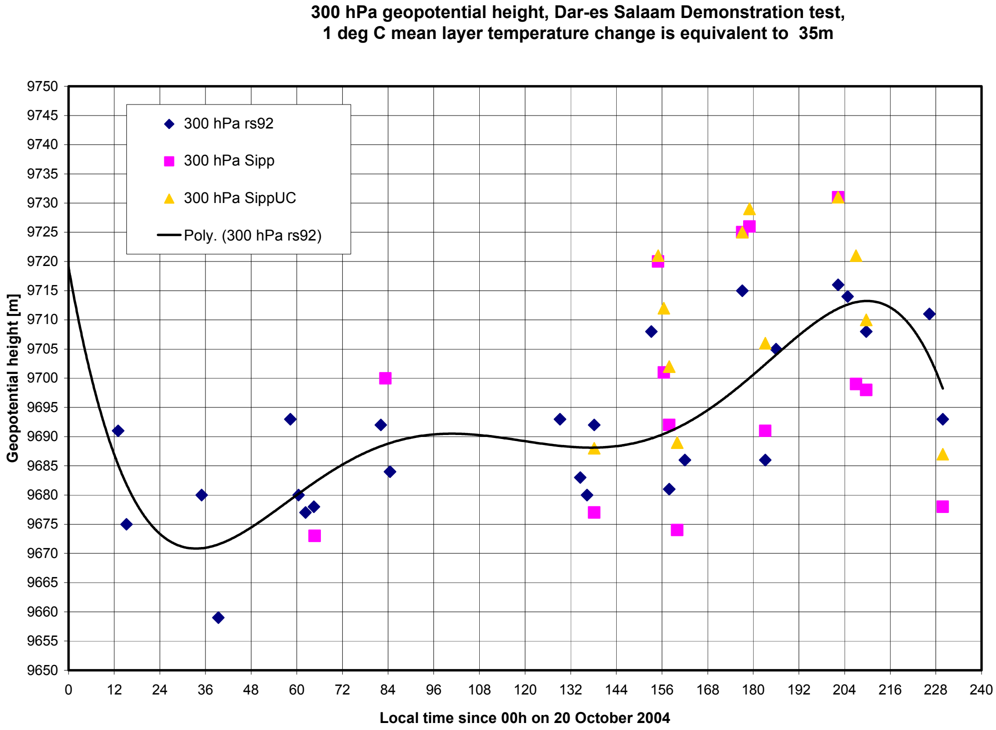

Fig.11(a) Time series of 300 hPa geopotential height for Vaisala (RS92) Sippican (Sipp) and Sippican uncorrected (Sipp UC) for the Dar-es-Salaam test, plus the polynomial fit to the Vaisala measurements.

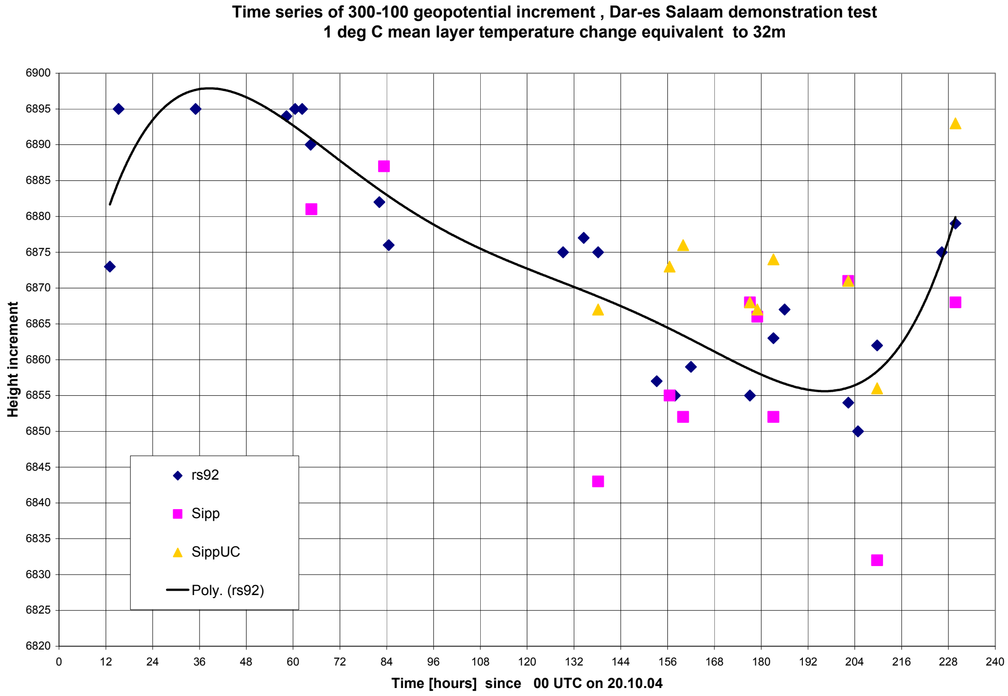

Fig. 11(b) Time series of [300-100] hPa geopotential increment, as for Fig.11 (a). The resultant systematic difference between the polynomial fit and the actual measurements as a function of time of day are shown in Figs. 12(a) and (b).

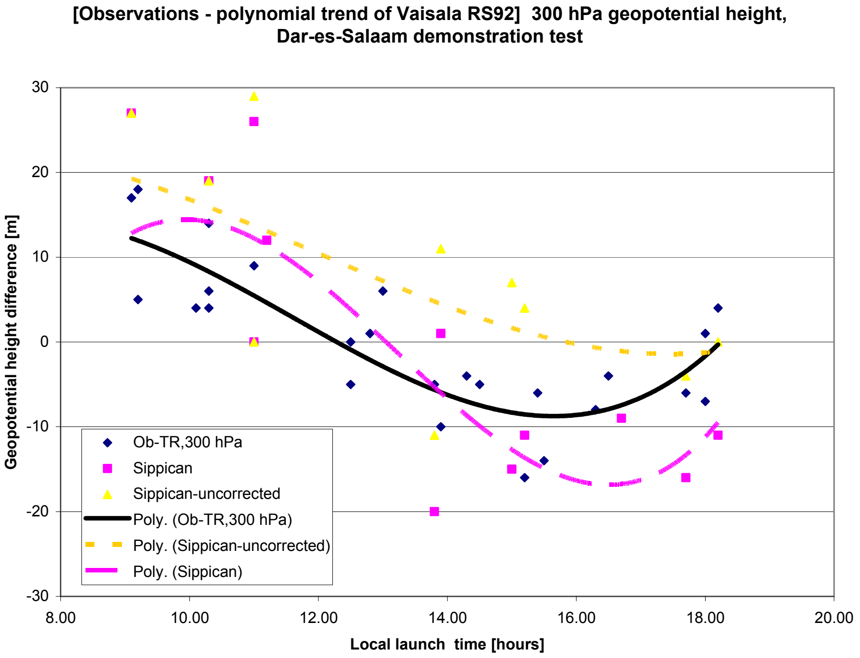

Fig 12(a) Differences between 300 hPa geopotential height measurements and the polynomial trend line [3rd order] fitted to the time series of Vaisala measurements.

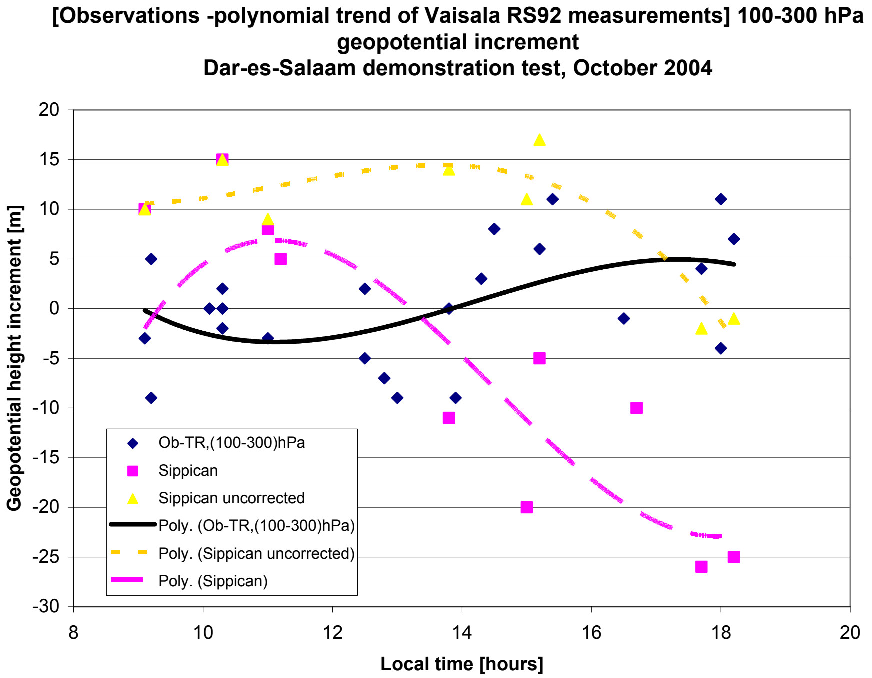

Fig.12(b) Differences between [300-100] geopotential increment measurements and the polynomial trend line [3rd order] fitted to the time series of Vaisala measurements.

The variation in 300 hPa geopotential with time of day shown by the Vaisala measurements in Fig 12(a) seems reasonable, as it is mostly caused by the semidiurnal variation of surface pressure. The uncorrected Sippican measurements also show the same variation with time of day from 09.00 to 16.00, since solar heating did not vary much with time of day during this period . The measurements at 18 UTC were essentially in the dark and do not have solar heating errors. Here Sippican uncorrected agrees with Vaisala. The Sippican corrected curve shows quite different variation with time of day, because the IMS ground station clearly had an error in its computation of local time. Thus IMS Sippican temperatures at 09.00 and 10.00 UTC had no corrections applied. The measurements at 18 UTC which should have no correction had daytime corrections applied and are too low on average.

The amplitude of the errors induced by the faulty correction procedures are larger in the (300- 100) hPa increment. At this level the daily variation in thickness is not influenced by the semidiurnal variation in surface pressure and there was probably a weak solar diurnal tide. The daily height variation in IMS Sippican is clearly wrong in Fig.12(b) , as a consequence of the errors introduced by the faulty local time computation in the correction software.

5.3 Twinflight comparison between Vaisala and IMS Sippican

A night time comparison between Vaisala and IMS Sippican and IMS Sippican uncorrected is shown in Fig.13. Here, the Sippican uncorrected measurement agrees very closely to the Vaisala measurement, all the way through the flight. The correction applied would appear appropriate to daytime conditions for a chip thermistor, but the much larger corrections applied at later times in the flight [after minute 70] seem quite inappropriate for chip thermistors.

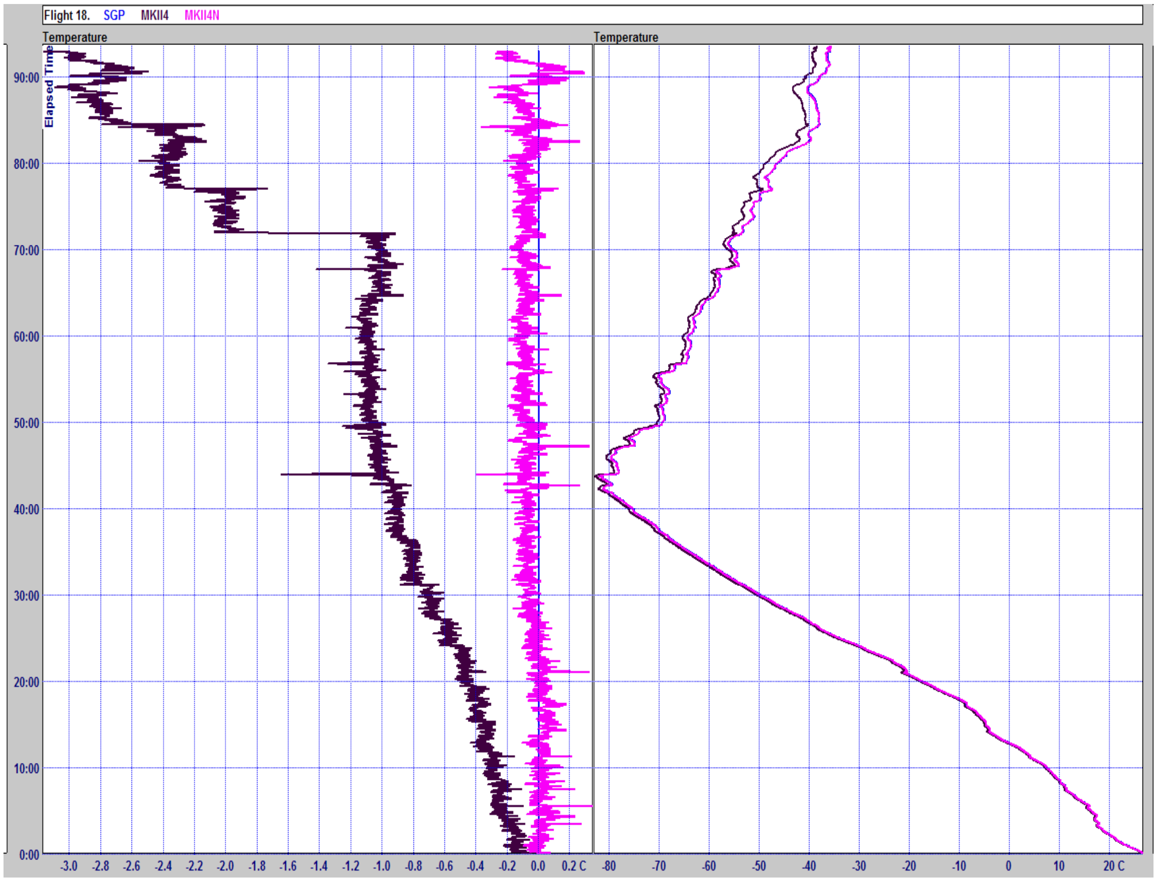

Fig.13 Simultaneous comparison between Sippican MkII and Vaisala RS92 temperature in dark conditions. The vertical blue line in the left hand panel is the Vaisala measurement used as a reference for temperature differences. Actual values are shown in the right hand panel

Sippican had not supplied radiation corrections to be used with these radiosondes. The origin of the corrections used by IMS was not documented by IMS and was not supplied to the test team. Hence , we have recommended that for the moment no correction is applied to operational flights in Tanzania.

<u>This indicates an inherent weakness in the Universal system approach. This universal concept will only work for GCOS if IMS and the radiosonde vendors work together to ensure that correction software is relevant to the radiosonde supplied and updated as the radiosonde manufacturer amends the design. All the smaller radiosonde manufacturers are changing their designs every two or three years at the moment so close collaboration is vital.</u>

Relative humidity measurements from the IMS Sippican combination appeared consistent with known Sippican performance. Fig. 14 shows an example of simultaneous comparisons with the Vaisala RS92 on a nighttime flight.

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Fig. 14 Simultaneous measurements of temperature and relative humidity, Sippican MkII and Vaisala RS92 (SGP)

In Fig. 14 the measurements of the two radiosonde agree well in the lower troposphere, but start to disagree more once the temperature is lower than about -30 deg C. Many other tests have shown that the carbon hygristor does not respond very well at these lower temperatures. This flight went through cirrus cloud between minutes 30 and 50, so it is doubtful whether either radiosonde sensor gave the correct relative humidity in this cloud.

6.4 Twin flights between Vaisala and MODEM GL

Fig.15 shows the differences IMS MODEM –Vaisala for simultaneous height and pressure measurements from a flight at night.

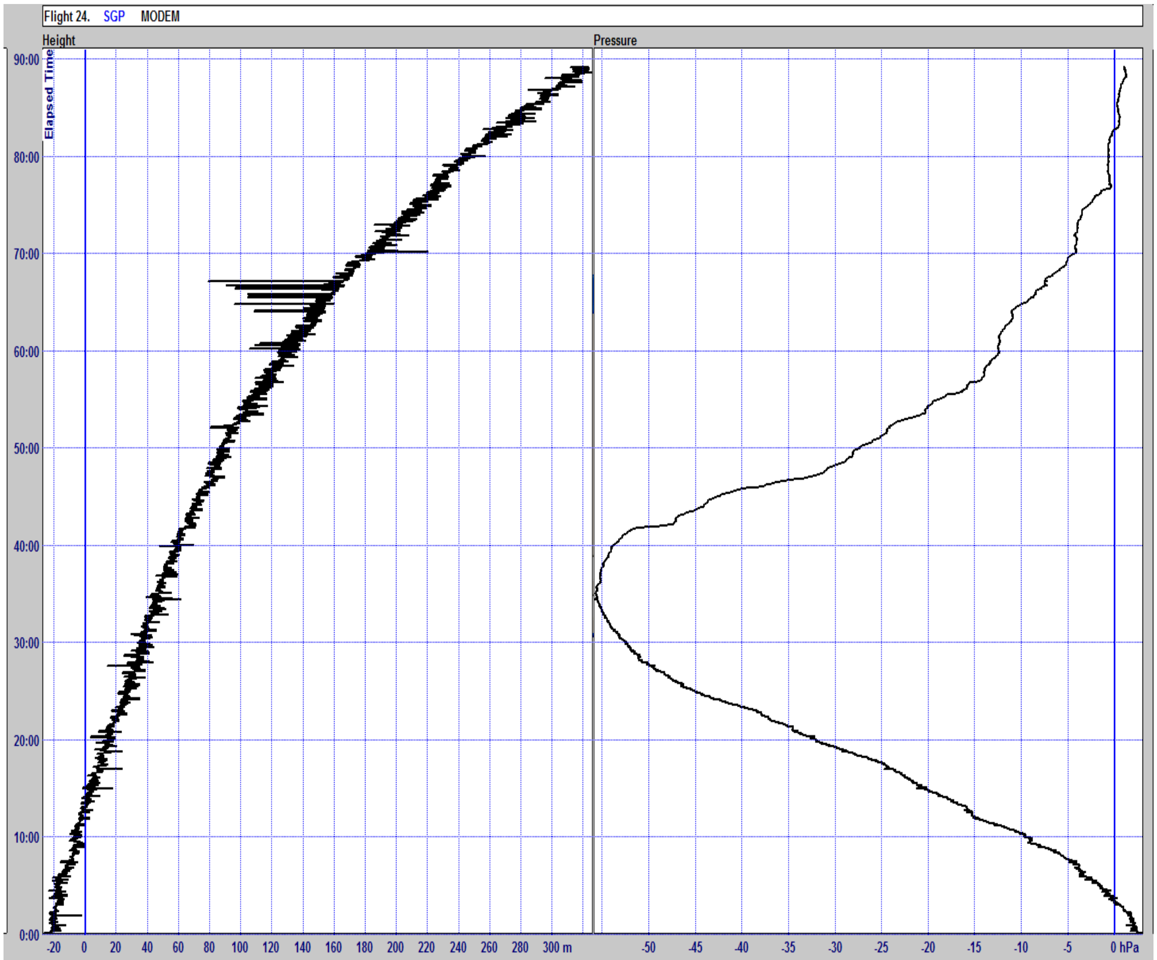

Fig. 15 Simultaneous comparisons[IMS MODEM-Vaisala] for height measurements in left hand panel and pressure in right hand panel.

This shows that the GPS geometric heights computed by the MODEM radiosonde were reasonable compared to the geopotential height computed by the radiosonde. If the height differences at minute 35 [14 km] were turned into equivalent pressure error this would be between 1 and 2 hPa, yet it is clear that the IMS pressure calculation from the height and temperature reported is giving 50 hPa error. The effect of this error in the operational output was that the 100 hPa geopotential heights were reported by the IMS MODEM system as near 14 km rather than around 16.5 km. This pressure error prevents any operational use of the MODEM radiosondes until the computation error is corrected.
The 20 m difference between MODEM GPS height and Vaisala height may be the result of a problem in referencing the MODEM height near the surface.

Collaboration between IMS and MODEM is currently very poor. The test team were contacted by MODEM before the test, indicating that MODEM took no responsibility for the results that would be obtained. The temperatures from the MODEM radiosondes + IMS decoder gave errors larger than 1 deg C in the stratosphere. The IMS MODEM relative humidity measurements were of variable quality and not reliable at all after 20 minutes into flight. It was impossible to determine whether the faults were in the radiosondes or in the decoders or the IMS software .The correction procedures for the

MODEM radiosondes were not documented or provided to the test team. It was impossible to trace what was happening, and the test team did not pursue any further investigations of the IMS MODEM system.

6. Quality of Measurements from Dar-es-Salaam issued onto the GTS since the demonstration test.

The number of measurements reaching the Met Office from Dar-es-Salaam in December was low, but the number increased in January, see Fig. 16. One flight produced anomalous results with a positive bias of about 600 m in the 100 hPa geopotential height

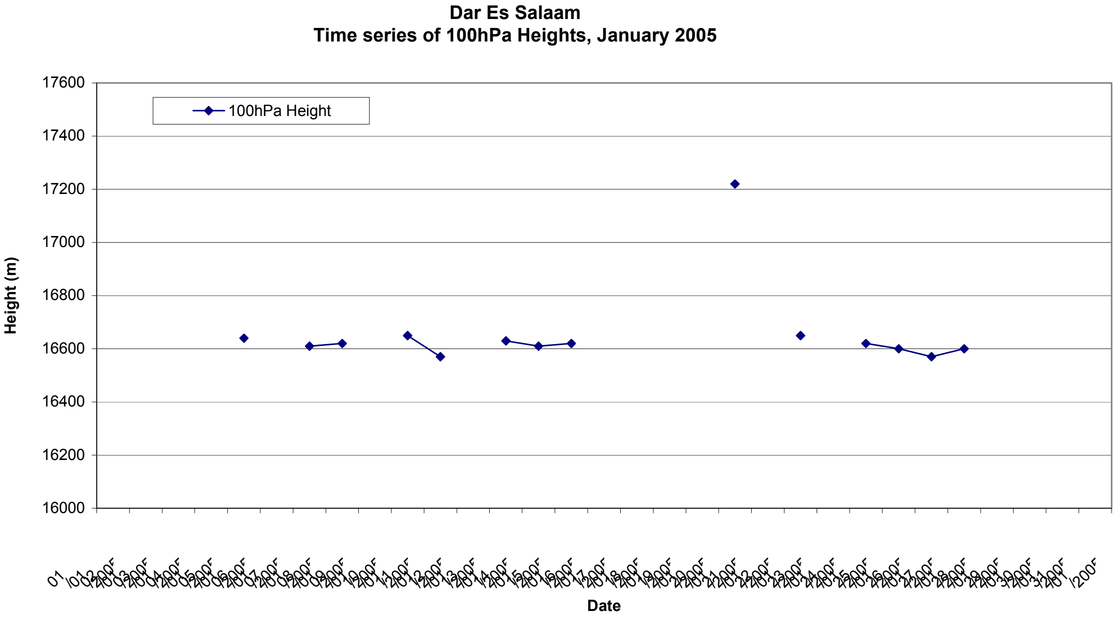

Fig. 16 Time series of 100 hPa geopotential heights received from Dar-es-Salaam in January 2005.

During the demonstration test , only Part A and C of the TEMP message were received at Exeter. Annex B gives the details of what has been received at Exeter since that time.
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Message generation and communication problems were not resolved during the demonstration. In the long term a system needs to be set up so the messages can be transmitted from the IMS ground station directly into the telecommunications network, without any need to type message manually into a communications interface.

It should be considered whether suitable software {Procomm+) should be used to communicate the messages directly to Exeter on a standard telephone link, similar to the communications implemented for the Gan radiosonde station in the Maldives. This should avoid the problems of Part B and D being missing most of the time.

7. Conclusions

7.1 The IMS 1600 system clearly needed more testing than had occurred before it was deployed in Tanzania. A lot of the system outputs were inconsistent within the various parts of the software, see the report of C. Bower, Annex A.

7.2 The tracking of the radiotheodolite appeared good and able to meet user requirements for wind in the tropics. The algorithms used for generating winds were not computing values at the resolution needed [or indicated by the software settings], i.e. 1 minute near the ground and 1 to 4 minutes in the stratosphere.

7.3 Mounting the radiotheodolite on the roof in Dar-es-Salaam hinders automatic tracking of the radiosonde at launch. Launch routines would be easier if the radiotheodolite were mounted on the ground [probably somewhere near the place here the old Vaisala radiotheodolite was stored.] Then , the person who launched the balloon could be responsible for checking that it was tracking on the main beam. Note the problem at Dar-es –Salaam occurs because the balloon shed is significantly lower than the building on which the radiotheodolite is mounted.

7.4 Correction procedures for Sippican and MODEM temperature measurements were not traceable by the test team. Neither radiosonde manufacturer appeared to have collaborated closely with IMS in ensuring that corrections applied were relevant to the radiosonde type provided for this demonstration.

7.5 IMS SIPPICAN measurements were fit for operational use, but the temperature correction procedures should not be used until the errors are rectified by IMS. This has now been rectified.

7.6 IMS MODEM system measurements were unfit for operations because of a very large pressure computation error that corrupted all reported data, particularly in the upper troposphere and lower stratosphere.

7.7 IMS message generation was not appropriate for TEMP messages in Region 1. This has now been rectified.

7.8 Further action is required to provide a more reliable method of communicating data from Dar-es-Salaam onto the GTS.

7.9 Re-establishing radiosonde measurements in a location such as Dar-es-Salaam where radiosonde ascents had not been made for more than 10 years requires a concerted training effort with staff present from both the manufacturer and from a National Meteorological Service with the necessary experience in radiosonde operations.

7.10 It would be beneficial if a suitable expert was sent to Tanzania to complete the training started during the demonstration test and to implement improved communications. This should be considered once IMS are ready to upgrade the system software.

7.11 The hydrogen generator installation worked well and is clearly capable of supporting the use of 800 or 1000g balloons on a regular basis. It is recommended that suitable funding be provided for the use of the larger balloons at Dar-es-Salaam in the long term.

Acknowledgments:

The demonstration test team were extremely grateful for the help and support provided by all Tanzania Meteorological Agency staff . In particular , we acknowledge the contribution of:-

M.R. Mtitu, Dan Jones, Lemmy Mganga, Samwel Mbuya, SedricK Ndonde, Habiba Mtongori .

Annex A

Preliminary report of Carl Bower on the demonstration test.

[Limited editing by J. Nash]. Please note the detailed analysis of the problems with the messages generated**.**

IMS1500 Message Coding and Data Tables Evaluation

Recommendations:

IMS 1500C would be better situated on the ground vice the rooftop of the observatory. The operator has to climb a ladder to get onto the roof to operate the CDU and get lock. It should be located where the old Vaisala tracker was located on the ground. Old conduit from the installation remains and could perhaps be used to pull cable through. This would enable launching right out of the balloon inflation area and using the CDU to track after release.

Message coding software needs to be modified to be Region I compliant. Additionally, software bugs need to be fixed so that the operators are not required to do message editing before message transmission. Please see list of software deficiencies.

Communication links need to be established to get the coded message out vice having to re-keystroke it at the communications center.

Future installations need to consider all aspects of training—not just how to operate an IMS system. Unfortunately, in the case of Dar es Salaam, upper air radiosonde flights had not been conducted since the early 90s. Consequently, meteorological aspects of upper air were unknown as well as process and procedure for flight preparation to include baseline activities, sonde preparation, flight train preparation, balloon inflation, hydrogen safety, etc.

The radiation correction required to operate radiosondes with a universal system will need to be provided by the radiosonde provider.

A radiosonde flight performance monitoring program needs to be put in place to determine if the site is operational on a day-to-day basis and if flights are not being transmitted/and or received at data centrals the sites need to be queried.

Maintenance support beyond the one year Warranty period need to be put in place to get vendor provided support. This may be an issue that GCOS will have to fund.

Recommend that Modem 403 GPS sondes not be considered as their use with the 1680 MHz tracker provided spurious results and the radiosonde provided will be going out of production.

Recommend that if GCOS wants to consider a dual frequency system, the 1680 MHz tracker idea be shelved and the use of GPS should be the choice because it is a less complicated system to use than an RDF tracker.

Recommend the use of the RDF universal system if cost of radiosondes is the issue. While it is more complicated to use than GPS, the operational costs are less.

Recommend software coding issues and disconnects between coded messages, standard levels tables for thermodynamic data, significant levels tables for thermodynamic data, and significant levels data for winds be cleaned up and be made consistent with the surface observation data.

Recommend that the pressure offset between the radiosonde and the reference be established as well as the altitude offset between the radiosonde baseline elevation and the release elevation.

Recommend that training materials be pulled together for an upper air program and be provided to TMA for the Dar Es Salaam site for use by the observers. This should include procedures for balloon storage, balloon preparation, balloon inflation, radiosonde baselining, flight train preparation, flight release, message coding, data archival, quality assurance activities etc. Currently, this information is not on station.

WMO Message Coding Findings and Software inconsistencies:

The 51515 Group is incorrect for Region I. The Region IV Group is in the software. For this group from FM 35 TEMP , Vol II WMO Code Manual 306, Paragraph 1/35.1 Part B, Section 9 shall be used in the region in the following form:

51515 $77h_7h_7h_7$ $T_7T_7T_{a7}\ D_7D_7$ $d_7d_7f_7f_7f_7$

$60h_6h_6h_6$ $T_6T_6T_{a6}\ D_6D_6$ $d_6d_6f_6f_6f_6$

The 77 group is for the 775 hPa level and the 60 is for the 600 hPa level
H is geopotential height
T is temperature
a is the decimal indicator
D is dewpoint depression
dd is direction
ff is speed

Part B, Section 4, of FM 32 Pilot, Region IV Volume II WMO Code Manual 306, Paragraph 1/32.2 needs to be included as follows: In addition to wind data at significant levels, altitudes of which shall be reported in geopotential units, data shall be included, as available, for the following altitudes: 600, 900, 2100, 3900, 4500, and 5100 m. (African sites do not seem to be doing this. Am trying to confirm this with the WMO Codes working group).

Part D, Section 4, of FM 32 Pilot, Region IV Volume II WMO Code Manual 306, Paragraph 1/32.4.1 needs to be included as follows: In addition to wind data at significant levels, altitudes of which shall be reported in geopotential units, data shall be included, as available, for the following altitudes: 21000, 24000, 27000, 30000, 33000, and all successive levels at 3000 m intervals, provided that they do not coincide with one of the reported significant levels. (African sites do not seem to be doing this. Am trying to confirm this with the WMO Codes working group).

Part D, Section 4, of FM 32 Pilot, Region IV Volume II WMO Code Manual 306, Paragraph 1/32.4.2 needs to be included: The altitudes 30000 m and above shall be encoded using units of 500 m, i.e., the altitudes 30000 and 33000 m shall be coded as 8606/, the altitudes 36000 and 39000 m as 8728/In addition to wind data at significant levels, altitudes of which shall be reported in geopotential units, data shall be included, as available, for the following altitudes: 21000, 24000, 27000, 30000, 33000, and all successive levels at 3000 m intervals, provided that they do not coincide with one of the reported significant levels.

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TTAA lacks the 31313 group. This is a WMO requirement. The TTAA includes the $s_r r_a r_a s_a s_a$ group and the 8GGgg group.

TTAA has the incorrect 51515 group for Region I. It has the one used in Region IV Part D.

TTBB lacks 51515 group in Part B, Section 9.

PPBB in one of the code forms available in the workstation is for Region IV--i.e., it is in feet. As nearly as can be determined, the 21212 group using pressure levels is the appropriate one to use. Need to tailor the computer to Region I practices and de-activate options available for other Regions.

PPBB wind coding for Region IV is incorrect. Levels reported in feet corresponding to standard levels such as 1000, 850, 700 hPa etc don't get coded in the PPBB because they are included in the TTAA part of the message.

TTCC lacks the 31313 group. This is a WMO requirement.

TTDD Section 7 lacks the 31313 $s_r r_a r_a s_a s_a$ group and the 8GGgg groups.

TTDD Section 1 in the identification and position data, the group YYGGI_d is incorrect. It should be YYGG/

PPDD has wind code field of 97259 but only shows one data field. Flight identified as 221400 in UQTN01. It is doubtful that this form should be used for Region I.

TTBB with combined 21212 pressure wind group has wrong 51515 group. Group does not have $s_r r_a r_a s_a s_a$ group before 8GGgg group.

TTAA lacks 31313 group with solar and lacks proper 51515 group for Region I.

TTCC lacks 31313 group.

TTDD lacks 31313 group.

Software lacks indicators for missing data for wind in Part D of FM 32. Specifically, it is not compliant with Paragraph 35.3.2.2 for Parts B and D.

The cloud code group 41414 is lacking in the TEMP 35 Part B, Section 8.

The 51515 group for Part B in the TEMP report is missing.

The WMO requirement for a mandatory significant level between the 110 and 100 hPa is not being met. It looks like the software does not have this function.

Solar radiation correction term is not able to discern time of day. It does not correct during day-light hours and then acts like the sun comes up and starts correcting. It the latitude looks like the software does not convert for the sign convention for latitude and longitude. Specifically, the longitude here at Dar Es Salaam is -+39.1862 (South)and the latitude is -6.86383 (East). Perhaps there is a station file where information for solar correction is configured and the configuration is incorrect.

It is not clear as to which radiation correction is being applied to the Mark II radiosonde with the chip thermistor. It looks like it may be one for the VIZ small rod. It is not consistent with corrections used by Sippican for the Chip thermistor. I suspect it is the correction derived from RADCOR and modified for the small rod thermistor. Three degrees correction in the stratosphere is far too great for the chip thermistor.

Flight file S00169a was a Modem flight. Modem pressure calculation scheme appears flawed. The flight detected balloon burst based on a period of increasing pressure. The height data however continued to increase. What is the pressure increase over time that will trigger a balloon burst determination? The pressure increased for about 32 seconds from time 4135 to 4177 seconds. The flight continued to ascend to termination.

The Standard Levels Summary includes the pressure levels of 900, 800, and 600 hPa. At one time these may have been 925, 775, and 600 hPa called for in Region I. 51515 group. The 775 may have been rounded to 800. The 925 hPa level is now a standard level in TTAA so has been dropped as a requirement in the 51515 Group for Region I.

Some of the software appears to be historical. It is suspected that it may go back to ATIR. Specifically, for the radiosonde type flown, in the 31313 group shows up as a 10. This was an old VIZ A sonde. It was last flown over 15 years ago.

Software needs to have capability to make pressure adjustment for elevation difference between reference barometer and baseline area for radiosonde. In the case of Dar El Salaam, they were different. The correction also needs to include an altitude adjustment for the difference between the reference barometer and the release point elevation.

Flight SO28TMA

> Data table for standard levels above 100 hPa has temperature data colder than dewpoint data.

Wind Direction in the surface observation summary never matches that in the standard and significant levels tables. The data for this flight showed up as 119.7 degrees but in the data table, it shows 2 degrees. This value is then incorrectly coded in the messages.

The first several levels on ascent rate off surface are too high. This was tracked down to use of sea level pressure vice station pressure for the surface observation.

Freezing level information in summary file does not match up with the level in the physical data output.

Tropopause data in the flight summary information has dewpoint temperature warmer than the temperature.

Maximum wind data shows a wind speed of 118 knots. This is not supported by the data. The problem resulted from locking onto a side lobe and then changing to the main lobe. This is a training issue. The elevation changed 14 degrees in a short period of time when the main lobe was acquired.

Software has regional codes for Region IV vice Region I in the TEMP code.

Coded message shows 360 degrees for surface wind and the data table shows 2 degrees. The surface observation showed 120 degrees.

The wind averaging interval is reported as being 250 seconds. This is over 4 minutes. For tropical areas this interval could be cut down to perhaps 2 minutes. This could provide more resolution.

Wind data is missing at the end of all flights even though the azimuth and elevation data are available. This is probably a function of the smoothing routine. The smoothing algorithm needs to be able to smooth data early in the flight to provide winds for the 1000, and 925 levels. For the beginning and end of a flight the smoother needs to be able to use shorter averaging periods until the full interval is realized.

Information such as radiosonde type such as 86 for the Sippican Mark II 1680 RDF chip thermistor sonde need to be in a station file so that it can readily be included in the 31313 group. The station information such as the ground tracker or measuring system used for the a_4 portion of the code form also needs to be included so that it can be used in the coded message.

The type of tracker being used needs to be part of a station file so that it can be used in the s_as_a portion of the 31313 group.

The type of solar correction needs to be specified in a station information file so that it is available for the coded message.

The release point elevation needs to be included in the station file so that it is available for the standard levels table.

The dewpoint values for all flights don’t calculate below 79.6 degrees C. It should be possible to calculate them to values less than 79.6. For example, with a temperature of -68 C, a pressure of 150 hPa, and a relative humidity of 13%, should be about minus 86. We need to be sure that we have dewpoint depression with respect to water and not the frost point,

Software needs to be tailored to regional and national practices. Various code forms in the files are confusing to the operators. They should only include the format for the station/region.

Annex B
Comments on Dar-es-Salaam flights received at Exeter

Mark Smees

Observations of Dar Es Salaam Flights

General Points

Only Parts A and C getting in, sometimes only one part either A or C.
There have been days when there are no ascents, or the flights are not in Met Office data store..
No Dew Point depression for temperatures below -40.
In section 1 (Identification and position) of the message the GG, (Actual time of observation, to the nearest whole hour UTC) is sometimes coded as 12 and other times as 11, despite similar launch times.

30/11/04 @ 10:23z

Only Part A in MetDB
Surface wind speed of 18 Kts in TEMP message. METAR @ 11z wind of 310/10kts, METAR @ 12z wind of 330/06kts. If they were using the Radiotheodolite, then possibility that they locked on to a side lobe, or launch position of the balloon was wrong.
The 100hPa height reported as 14130m, this is too low.
The 31313 group indicates that the radiosonde/sounding system used was 09 = No radiosonde – system unknown or not specified. And Tracking was 08 = Automatic satellite navigation.
Was a MODEM sonde launched?

01/12/04 @ 11:04z

Only Part A in MetDB
The 100hPa height reported as 14030m, this is too low.
The 31313 group indicates that the radiosonde/sounding system used was 09 = No radiosonde – system unknown or not specified. And Tracking was 08 = Automatic satellite navigation.
Was a MODEM sonde launched?

02/12/04 @ 12:05z

Only Part C in MetDB

03/12/04 @ ????

Only Part A in MetDB
Only data up to 500hPa, however coded information in part A section 1 (I_d) indicates that the flight went to at least 150hPa.
There was no 31313 group.

15/12/04 @ 10:42z

Parts A and C in MetDB

16/12/04 @ 10:42z and 11:04z

Both only had Parts A and C
Supposedly 2 flights on this day; the first launched at 10:42z which reached at least 50hPa, the second launched at 11:04z, only 22 minuets later (there is no way that the

first flight reached 50hPa in 22 minutes, let alone they prepared another sonde and launched it). Both flight have different information.
Note:- After further investigation the flight at 10:42z is the previous days flight (15th), however I do not know how the date was coded in the message to be the 16th.

17/12/04 @ 10:40z
Only Part A in MetDB
The 150hPa level is missing the wind group, if the wind is suspect then the group should be /////.

18/12/04 @ 10:36z
Only Part A in MetDB

9/12/04 @ 10:37z
Only Parts A and C in MetDB

20/12/04 @ 10:40z
Only Part A in MetDB
No data above 150hPa.

28/12/04 @ 10:35z
Only Part A in MetDB

05/01/05 @ 10:36z
For the first time there is a Part D in the MetDB, also a Part A
In part D the last selected points are at different levels, Temp at 28.5hPa and wind at 32.8hPa.

07/01/05@ 10:34z
Only Parts A and C in MetDB

08/01/05 @ 10:44z
Only Parts A and C in MetDB

10/01/05 @ 10:38z
Only Parts A and C in MetDB

11/01/05 @ 10:43z
Only Parts A and C in MetDB

13/01/05 @ 10:39z
Only Parts A and C in MetDB

14/01/05 @ 10:26z
Only Parts A and C in MetDB

15/01/05 @ 10:43z
Only Parts A and C in MetDB

18/01/05 @ 10:31z
Only Part C in MetDB

20/01/05 @ 10:32z
Only Part A in MetDB
Standard level heights are wrong, temperatures are suspect (around 10°C too high?).