Airborne Timelapse Photography of Convection and Thunderstorms Darwin/Australia November 2004

Technical Report

J.M. Hacker, S. Carroll and R. Gaissmaier

6 December 2004

Airborne Research Australia / Flinders University
www.AirborneResearch.com.au

ARA Technical Report No. 06-2004

Airborne Research Australia
PO Box 335
Salisbury South 5106

Ph: 08 8182 4000
Fax: 08 8285 6710

http://www.AirborneResearch.com.au

TABLE OF CONTENT

Overview

In November 2004, aerial timelapse photography of convection and thunderstorms was carried out during a collaborative research project between ARA – Airborne Research Australia/Flinders University, the BBC's Natural History Unit and Simon Carroll.

Two Canon EOS-D1s cameras were flown on ARA's ECO-Dimona aircraft (VH-EOS). One camera was mounted on the wingtip of the aircraft looking 90 degrees sideways, with the second camera mounted in an underwing pod looking sideways/forward under an angle of about 45 degrees.

The cameras were controlled from two computers within the cockpit of the aircraft. The images were also stored on these computers.

The aircraft was equipped with a GPS-based positioning and attitude system Trimble TANS Vector), giving the position and the attitude of the aircraft (latitude, longitude, altitude, pitch angle, roll angle and aircraft heading) at a data rate of 10 times per second. This data will be used to correct the images for aircraft movement.

Seven flights were carried out with a total of 26 flying hours.

For most of the time, the cameras were operated in a mode giving an image every six seconds. A total of 15,965 images were taken yielding 119GB of raw data.

To assist in the flight strategy, high-speed Internet connection was available during the whole flight enabling the display of the Darwin weather radars in realtime in the aircraft's cockpit.

Technical Information

The following times were used:

CST = Darwin Time = UTC + 9.5h
CDST = Adelaide Time = CST + 1h = UTC + 10.5h

GPSsec = seconds after midnight on the previous Sunday

JT = JREX system time (should be close to CDST)
JS = JT converted to seconds after midnight the previous Sunday, no offsets

VT = Vaio system time (should be close to CDST)
VS = as JS, but for VT

CAT = Camera time for ARA-camera as read in Canon FileViewer
CAS = as JS, but for CAT

CNT = Camera time for non ARA-camera as read in Canon FileViewer
CNS = as JS, but for CNT

The following cameras were used:

ARA camera: S/N 101634
Non-ARA camera: S/N 109895

The following computers were used in the aircraft:

VAIO: Sony Vaio Notebook PC
FUJI: Fujitsu Notebook PC
JREX: Kontron Industrial PC
TANSPC: Single-Board PC

GPS data:

Flights were on 20, 21, 22, 24, 25 and 26 November 2004.
GPS and attitude data is not available on 20 Nov.

The following number of images were taken:

Date of flight	wingtip camera	pod camera
20 Nov 2004	170	429
21 Nov	699	531
22 Nov	1493	305
24 Nov	1771	2133
25 Nov	2349	2746
26 Nov	1519	1820
TOTAL	8001	7964

Technical Information for the individual days

Fri 26 Nov 2004

Wingtip: Non-ARA camera recorded on JREX
Pod: ARA camera recorded on VAIO

First wingtip image: 0003 – 15:06:32JT = 486392JS 14:41:55CNT = 484915CNS
Last wingtip image: 1519 – 20:08:00JT = 504480JS 19:43:24CNT = 503004CNS
Time between first and last image: 18088s 18089s

First pod image: 0002 – 15:12:12VT = 486732VS 14:12:45CAT = 483165CAS
Last pod image: 1820 – 20:13:38VT = 504818VS 19:14:11CAT = 501251CAS
(27s after landing)
Time between first and last image: 18086s 18086s

Filename of Trimble GPS file: 15:36

TPsec : 446846,446847,...,467175,467178 9248 samples
TAsec: 446846,446846,...,467181,467181 202848 samples

Take-off at GPSsec = 447000 = 04:10:00UTC = 13:40:00CST
Landing at GPSSec = 467000 = 09:43:20UTC = 19:13:20CST
Flight time: 20000s = 5h 33m

The Trimble lost altitude for some reason during the final descent. Other GPS data is ok.

First wing wriggle should be first image of wingtip: found at GPSsec 448902 = 04:41:42UTC
Second wing wriggle should be first image of pod: found at GPSsec 448941 = 04:42:21UTC

wingtip camera: first image: 448902 (14:11:42CST) last image: 466990 (19:13:10CST)
pod camera: first image: 448941 (14:12:21CST) last image: 467027 (19:13:47CST)

According to this,

CNS is 448902 – 484915 = 36013 seconds (10:00:13) in front of UTC
CAS is 448941 – 483165 = 34224 seconds (09:30:24) in front of UTC

Thu 25 Nov 2004

Wingtip: Non-ARA camera recorded on JREX
Pod: ARA camera recorded on VAIO

First wingtip image: 0004 – 12:09:12JT = 389352JS 11:44:32CNT = 387872CNS
Last wingtip image: 2349 – 16:51:00JT = 406260JS 16:26:32CNT = 404792CNS
Time between first and last image: 16908s 16920s checked - correct

First pod image: 0002 – 11:58:12VT = 388692VS 10:58:44CAT = 385124CAS
Last pod image: 2746 – 16:56:46VT = 406606VS 15:57:18CAT = 403038CAS
Time between first and last image: 17914s 17914s

Filename of Trimble GPS file: 12:49

TPsec : 350132,350137,...,368922,368923 8484 samples
TAsec: 350134,350134,...,368934,368934 187716 samples

Take-off at GPSsec = 350500 = 01:21:40UTC = 10:51:40CST
Landing at GPSSec = 368700 = 06:25:00UTC = 15:55:00CST
Flight time: 18200s = 5h 03m 40s

Wing wriggles are not defined, so relative timing was used

I cannot see any wriggles on the attitude plot, therefore the relative timing from 26 Nov is used:
CNS 36013 seconds (10:00:13) in front of UTC
CAS 34224 seconds (09:30:24) in front of UTC

wingtip camera: first image: 351859 (11:14:19CST) last image: 368779 (15:56:19CST)
pod camera: first image: 350900 (10:58:20CST) last image: 368814 (15:56:54CST)

Wed 24 Nov 2004

Wingtip: Non-ARA camera recorded on JREX
Pod: ARA camera recorded on VAIO

First wingtip image: 0002 – 11:15:00JT = 299700JS 10:50:18CNT = 298218CNS
Last wingtip image: 1771 – 15:20:54JT = 314454JS 14:56:14CNT = 312974CNS
Time between first and last image: 14754s 14756s

First pod image: 0002 – 11:16:32VT = 299792VS 10:17:03CAT = 296223CAS
Last pod image: 2133 – 15:26:24VT = 314784VS 14:26:55CAT = 311215CAS
Time between first and last image: 14992s 14992s

Filename of Trimble GPS file: 12:04

TPsec : 261021,261023,...,277998,277999 7690 samples
TAsec: 261022,261022,...,278013,278014 169648 samples

Take-off at GPSsec = 261200 = 10:03:20CST
Landing at GPSSec = 277800 = 14:40:00CST
Flight time: 16600s = 4h 36m 40s

There are wriggles in the attitude track at GPSsec 262172, 262206 and 262241
From memory, the first wriggle was unsuccessful (camera did not start), so it is probably the second one.

Using the relative timing from 26 Nov:
CNS 36013 seconds (10:00:13) in front of UTC
CAS 34224 seconds (09:30:24) in front of UTC

wingtip camera: first image: 262205 (10:20:05CST) last image: 276961 (14:26:01CST)
pod camera: first image: 261999 (10:16:39CST) last image: 276991 (14:26:31CST)

This tallies well with the second wriggle, but not with the third.

Mon 22 Nov 2004

Wingtip: Non-ARA camera recorded on JREX
Pod: ARA camera recorded on VAIO

First wingtip image: 0001 – 15:29:26JT = 142166JS 15:04:38CNT = 140678CNS
Last wingtip image: 1502 – 19:39:00JT = 157140JS 19:14:14CNT = 155654CNS
Time between first and last image: 14974s 14976s

First pod image: 0001 – 15:38:16VT = 142696VS 14:38:48CAT = 139128CAS
Last pod image: 0305 – 19:03:56VT = 155036VS 18:04:27CAT = 151467CAS
Time between first and last image: 12340s 12339s

Filename of Trimble GPS file: 16:19

TPsec : 103777,103778,...,119763,119765 7340 samples
TAsec: 103911,103912,...,119768,119768 157851 samples

Take-off at GPSsec = 104340 = 14:29:00CST
Landing at GPSSec = 119450 = 18:40:50CST
Flight time: 15110s = 4h 11m 50s

There are wriggles in the attitude track at GPSsec 105712 and 105738, but they do not tally with the result below – check later. Perhaps the first image was not used, but the second one ??

Using the relative timing from 26 Nov:
CNS 36013 seconds (10:00:13) in front of UTC
CAS 34224 seconds (09:30:24) in front of UTC

wingtip camera: first image: 104665 (14:34:25CST) last image: 119641 (18:44:01CST)
pod camera: first image: 104904 (14:38:24CST) last image: 117243 (18:04:03CST)

wingtip 2nd image: 15:22:36JT = 141756JS yields: 105743 which is very close to the second wriggle
pod 2nd image: 14:50:27VT = 139827VS yields: 105603 which is not related to a wriggle

Sun 21 Nov 2004

Wingtip: ARA camera recorded on FUJI (?)
Pod: non-ARA camera recorded on VAIO (?)

First wingtip image: 0022 – 17:52:24CAT = 64344CAS
Last wingtip image: 0699 – 19:26:07CAT = 69967CAS
Time between first and last image: 5623s

First pod image: 0001 – 18:23:26CAT = 66206CAS
Last pod image: 1733 – 19:51:23CAT = 71483CAS
Time between first and last image: 5277s

Filename of Trimble GPS file: 18:42

TPsec : 25696.8,25698.3,...,35953.3,35954.8 4700 samples
TAsec: 25697.9,25698,...,35588.7,35588.8 98742 samples

Take-off at GPSsec = = CST (not in file)
Landing at GPSSec = 35300 = CST
Flight time:

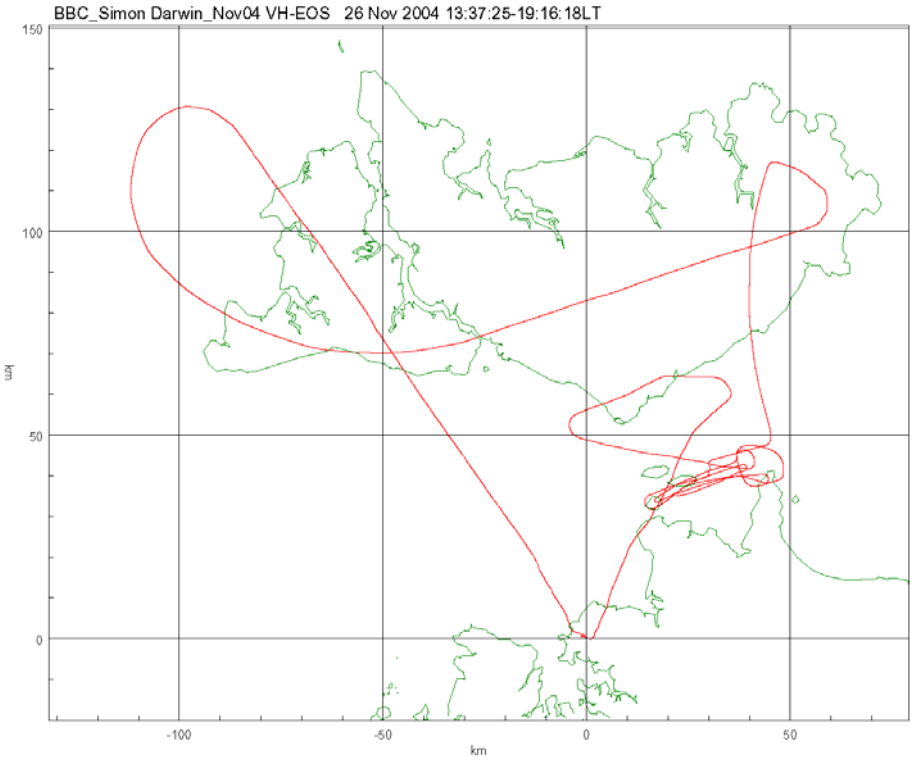
There are wriggles in the attitude track at GPSsec 30121 and 30195.They confirm the result below.

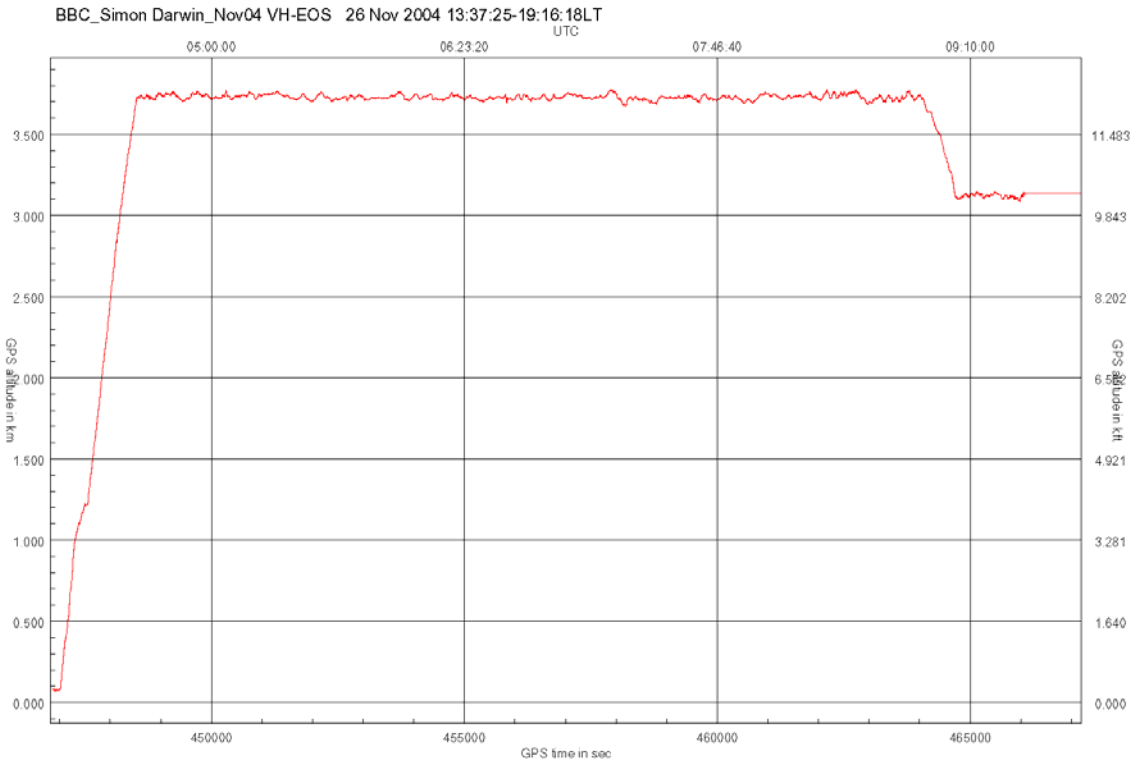
Using the relative timing from 26 Nov (CAUTION: camera set-up different):
CNS 36013 seconds (10:00:13) in front of UTC
CAS 34224 seconds (09:30:24) in front of UTC

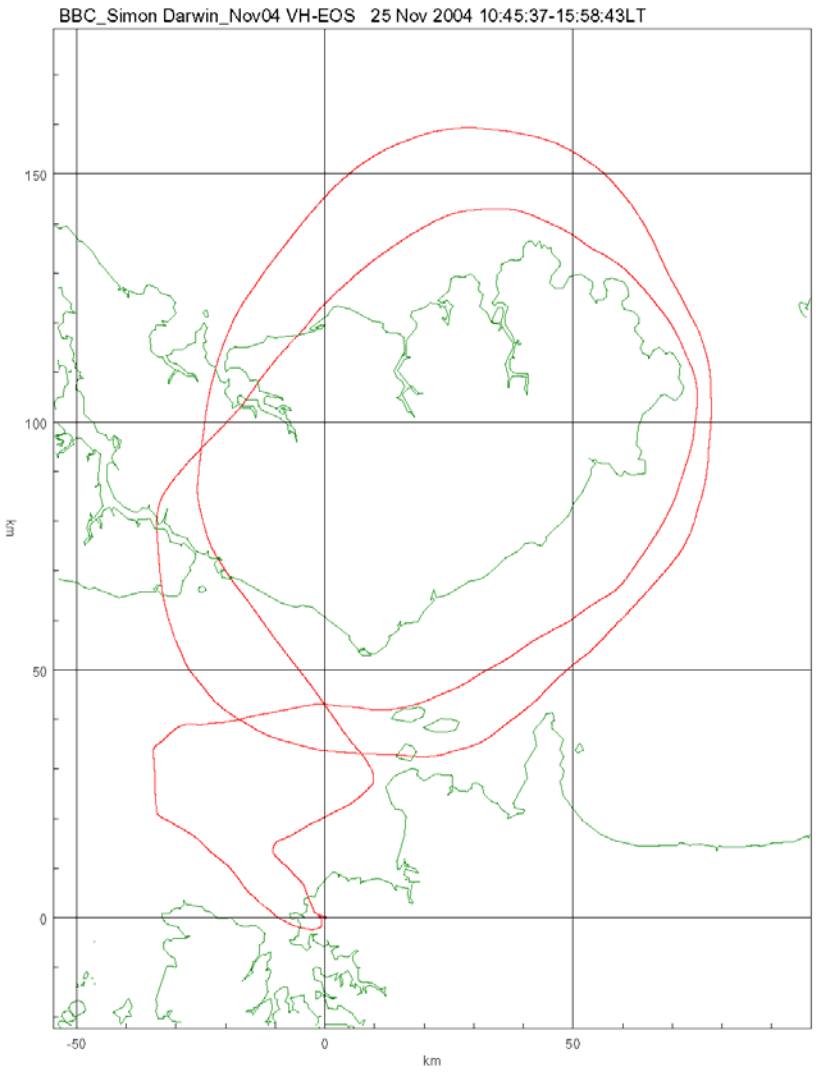
wingtip camera: first image: 30120 (17:52:00CST) last image: 35743 (19:25:43CST)
pod camera: first image: 30193 (17:53:13CST) last image: 35470 (19:21:10CST)

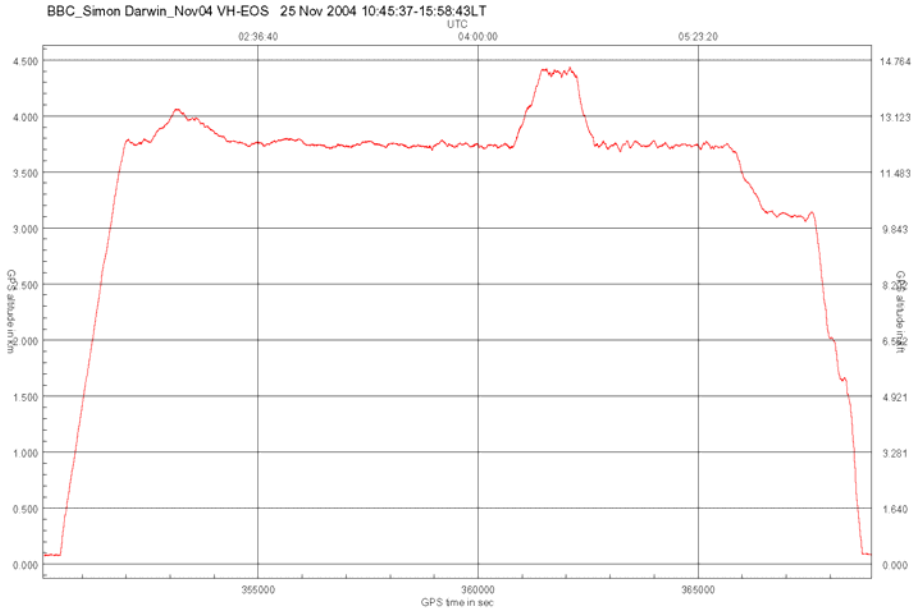
Flight tracks for the individual days

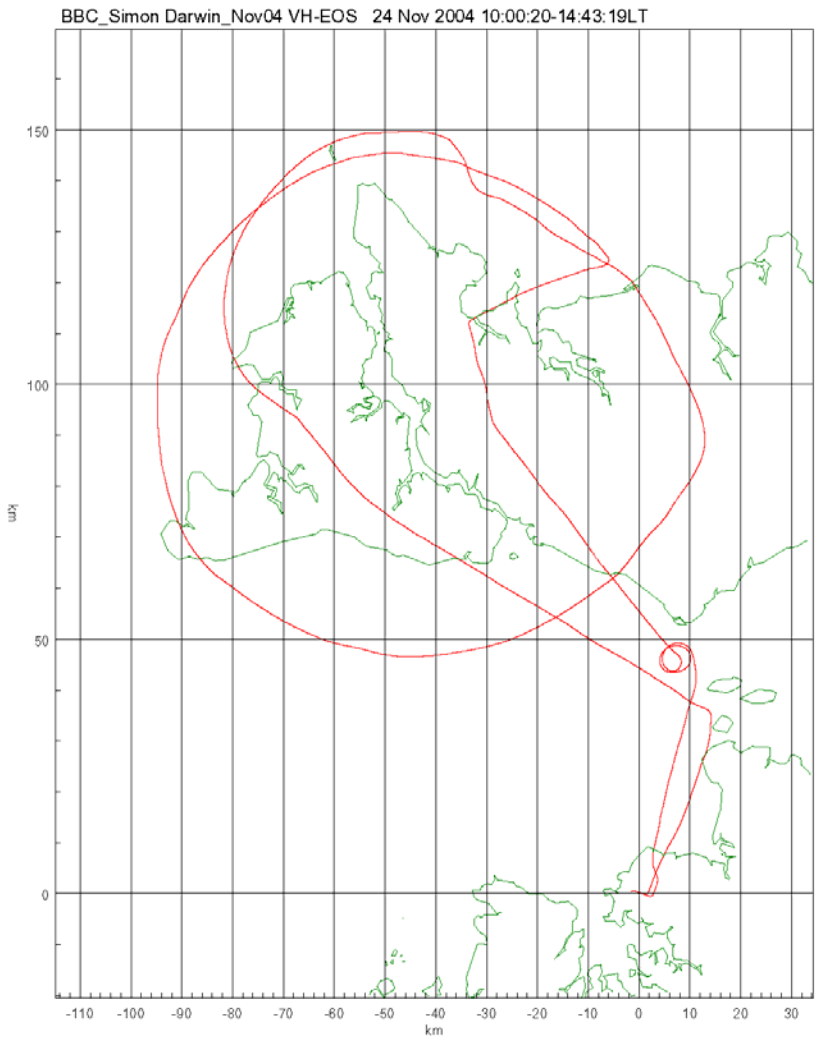
The following figures show the flight tracks and altitude plots of the flights. The flight on 20 November is not shown, as there was no GPS data available on this day.

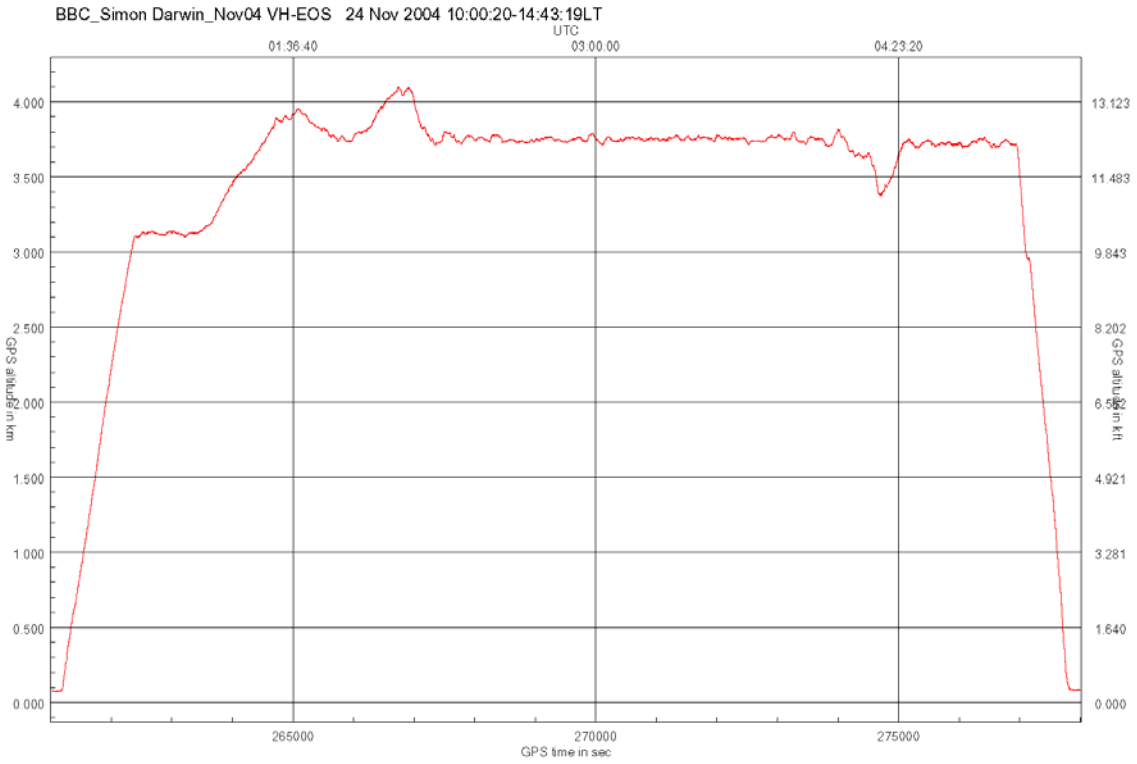


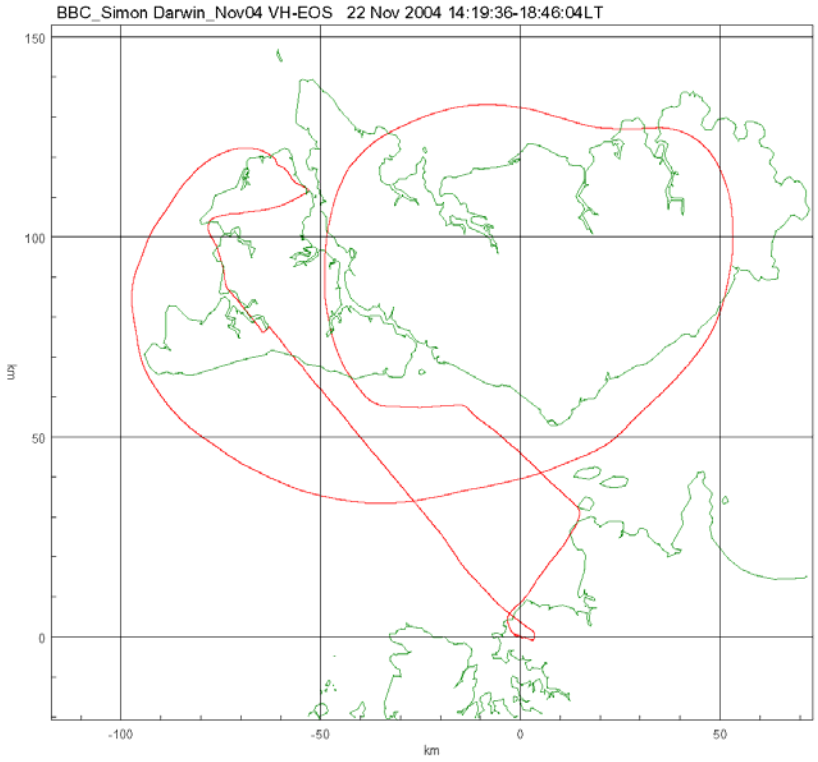


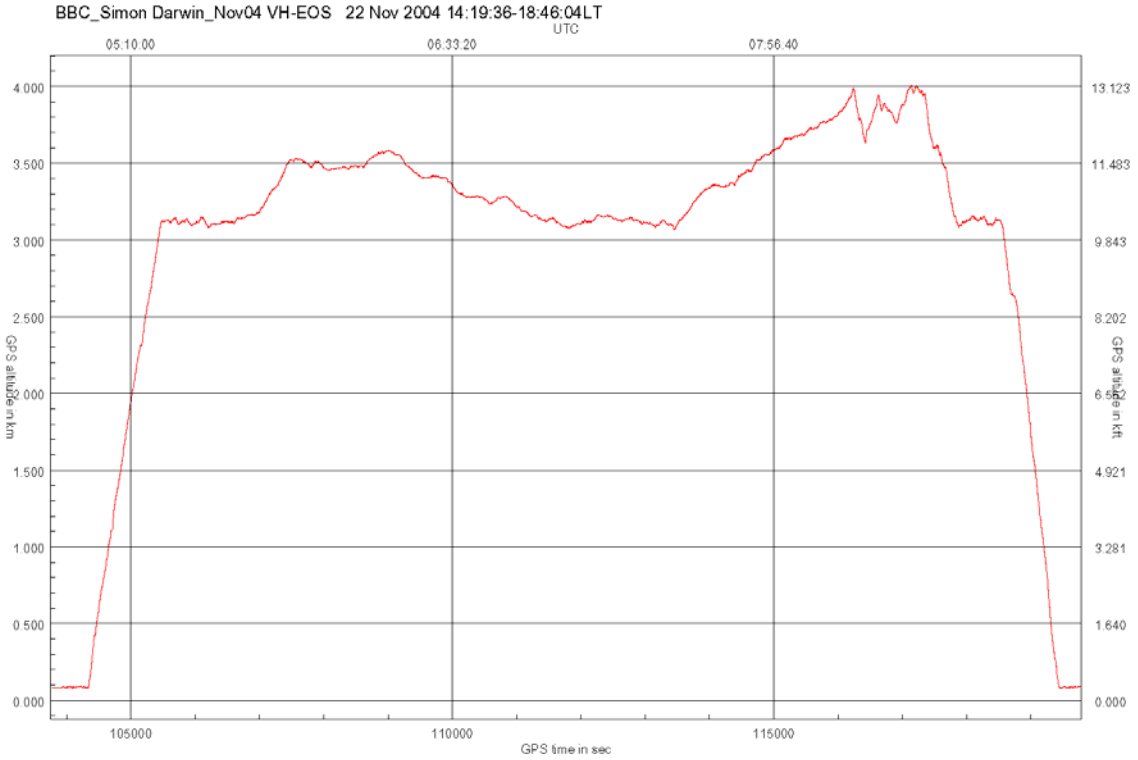

BBC_Simon Darwin_Nov04 VH-EOS 25 Nov 2004 10:45:37-15:58:43LT
150
100
50
0
km
-50
0
50
km

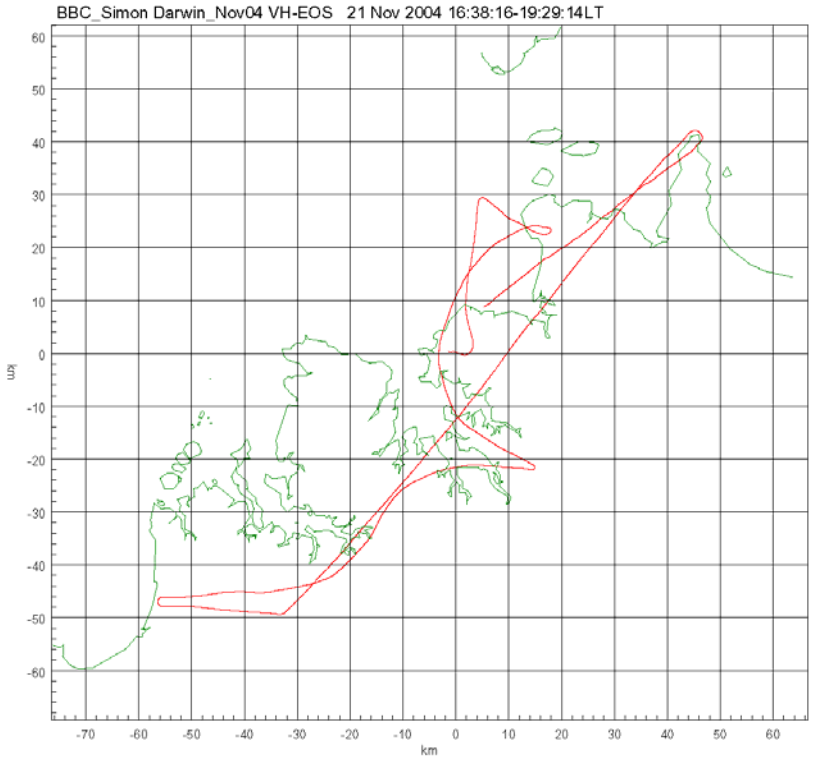

BBC_Simon Darwin_Nov04 VH-EOS 25 Nov 2004 10:45:37-15:58:43LT
UTC
02:36:40
04:00:00
05:23:20
4.500
4.000
3.500
3.000
2.500
2.000
1.500
1.000
0.500
0.000
14.764
13.123
11.483
9.843
8.202
6.562
4.921
3.281
1.640
0.000
GPS altitude in km
GPS altitude in ft
355000
360000
365000
GPS time in sec

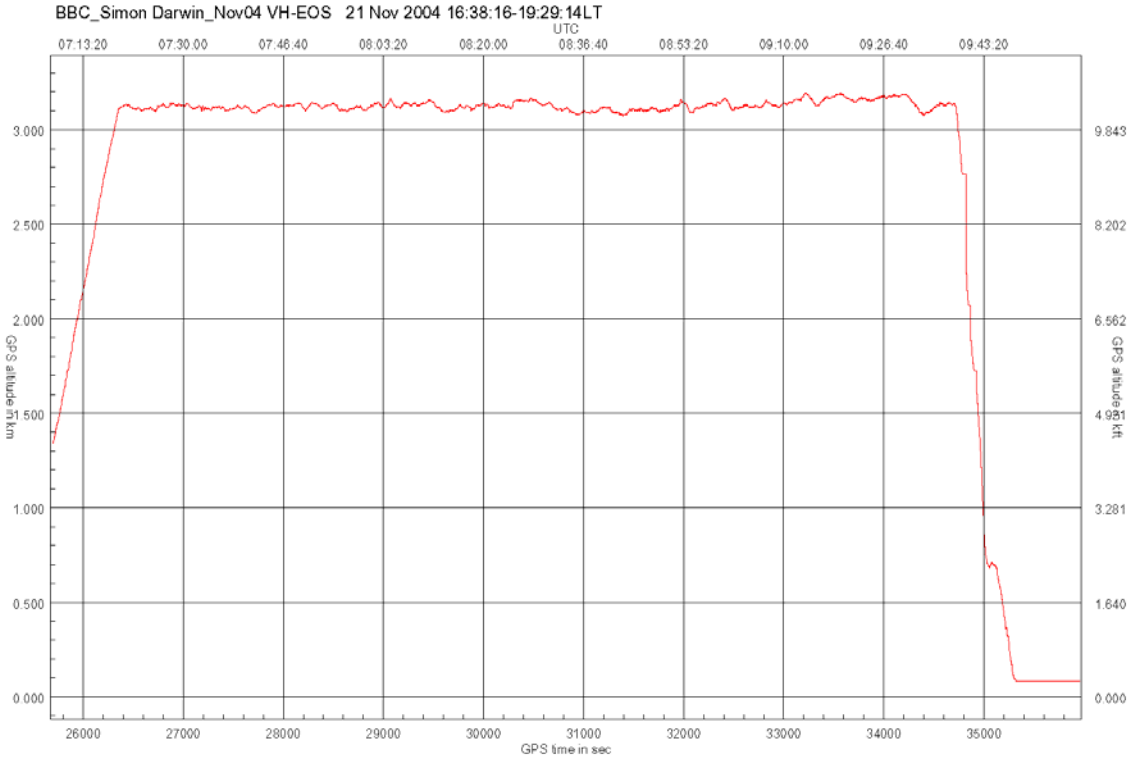

BBC_Simon Darwin_Nov04 VH-EOS 24 Nov 2004 10:00:20-14:43:19LT
150
100
50
0
km
-110 -100 -90 -80 -70 -60 -50 -40 -30 -20 -10 0 10 20 30
km


BBC_Simon Darwin_Nov04 VH-EOS 24 Nov 2004 10:00:20-14:43:19LT
UTC
01:36:40
03:00:00
04:23:20
4.000
3.500
3.000
2.500
2.000
1.500
1.000
0.500
0.000
GPS altitude in km
13.123
11.483
9.843
8.202
6.562
4.921
3.281
1.640
0.000
GPS altitude in kft
265000
270000
275000
GPS time in sec


BBC_Simon Darwin_Nov04 VH-EOS 22 Nov 2004 14:19:36-18:46:04LT
150
100
50
0
km
-100
-50
0
50
km


BBC_Simon Darwin_Nov04 VH-EOS 22 Nov 2004 14:19:36-18:46:04LT
UTC
05:10:00
06:33:20
07:56:40
4.000
3.500
3.000
2.500
2.000
1.500
1.000
0.500
0.000
GPS altitude in km
13.123
11.483
9.843
8.202
6.562
4.921
3.281
1.640
0.000
GPS altitude in kft
105000
110000
115000
GPS time in sec


BBC_Simon Darwin_Nov04 VH-EOS 21 Nov 2004 16:38:16-19:29:14LT
km
km


BBC_Simon Darwin_Nov04 VH-EOS 21 Nov 2004 16:38:16-19:29:14LT
UTC
GPS altitude in km
GPS altitude in kft
GPS time in sec

Acknowledgements

We wish to thank the following organisations and individuals:

- the Royal Australian Airforce (RAAF) for allowing us to use their facilities at Darwin RAAF Base;
- Ms. Rhona Godward from Pearl Flight Centre / Darwin for arranging many logistics requirements;
- the Australian Bureau of Meteorology for access to their weather radar and for forecasting assistance;
- the Air Traffic Controllers at Darwin and at Brisbane for accommodating the strange flight paths requested;
- the Marrakai Apartments for giving us one of the apartments in the 14th floor with direct view of the thunderstorms; and
- Shakti for looking after the well-being of the whole team.