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Comparison of codes used for cosmic radiation dosimetry

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On behalf of EURADOS WG5:
Aircrew Dosimetry

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EURADOS WG5 on *Aircrew Dosimetry*

The objectives:

- Provide advices for **harmonisation** of the **aircrew dosimetry practices** in European countries
- **Maintain the expert knowledge** in the aircrew dosimetry field, in order to assure the continuity of the progress achieved and to disseminate appropriate information to stakeholders
- Provide **notification** in case of a *Ground Level Event*

Example of notification

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Microbeam Workshop

Newsletter No: 16 || Category: Reports || Secondary Category: EURADOS || Story ID: 50105 || Submitted on: 2005-02-11 11:43

EURADOS Aircraft Crew Dosimetry Group assessment of doses

Notification of Ground Level Event: January 20, 2005

A Solar Particle Event (SPE) took place in January 20th 2005, starting at 0650 UTC with maximum intensity at around 0700 UTC. This event was sufficiently energetic to be detected by ground level neutron monitors (GLNM) and will be registered as a Ground Level Event (GLE68 or 69).

In the polar regions, where the Earth is less shielded by its magnetic field, the GLNM count rate increased relative to the count rate between January 14th and January 16th by 125% locally (NM Oulu, hour average) in the northern hemisphere and up to 380% locally (NM South Pole, hour average) in the southern hemisphere. The increased count rates fell off markedly with decreasing magnetic latitude, and so one can expect that only high latitudes (>60°) were significantly affected.

The intensity fell off rapidly after its maximum, and the duration was relatively short - around 6 hours. Preliminary evaluations of probable doses to aircraft crew flying at the time have been made by several groups. For normal aircraft altitudes and for higher latitudes, for instance for Europe to US west coast or Japan routes, initial estimates indicate that the additional doses should not exceed 200 µSv/flight.

Final estimates will be produced after analysis of satellite and ground monitors data, and any in-flight measurements results.

Submitted by: Dr. David T. Bartlett , National Radiological Protection Board , NRPB , Oxon , United Kingdom
Responsible editor: Francesco d`Errico

Objectives of the code comparison

Key comparison of codes, some of them used routinely, to assess the dose received by aircraft crew caused by galactic cosmic radiations (GCR)

List of investigated codes and their status

AVIDOS 1.0 *(EC accredit, commercial)*

CARI6* *(free)*

EPCARD.NET5.4.0 *(to be approved by LBA, commercial)*

FDOScalc *(non commercial)*

FREE1.3.0 *(LBA approved, commercial)*

PCAIRE *(LBA approved, commercial)*

PLANETOCOSMICS** *(scientific version)*

QARM1.0 *(engineering model, commercial)*

SIEVERT1.0 *(IRSN approved, commercial)*

* *Results not yet provided, will be included in the final report*
** *Preliminary results only, not presented here but in the final report*

Key aspects

The key aspects of this comparison are:

- Calculation of the **effective dose (*E*)**, *the protection quantity used in radiation protection for risk management*, and the **ambient dose equivalent (*H*(10)*)**, *the operational quantity used for comparison with measurements for the validation of the codes*
- **23 flights** all over the world, including 7 Ultra Long Range (duration > 13h)
- **Solar activity**: Solar max: 07/2000 and Solar min: 09/2007

23 flights selected

Departure	Destination
LFPG	KJFK
KJFK	LFPG
LFPG	KIAD
KSFO	LFPG
LFPG	KSFO
LFPG	SBGL
RJAA	LFPG
LFPG	RJAA
LFPG	FAJS
FAJS	LFPG
WSSS	KEWR
OMDB	KIAH
KORD	ZBAA
KORD	ZSPD
KORD	VHHH
YSSY	VTBD
YSSY	VHHH
YSSY	FAJS
FAJS	YSSY
YSSY	FAJS
WSSS	YSSY
WSSS	NZAA
NZAA	WSSS

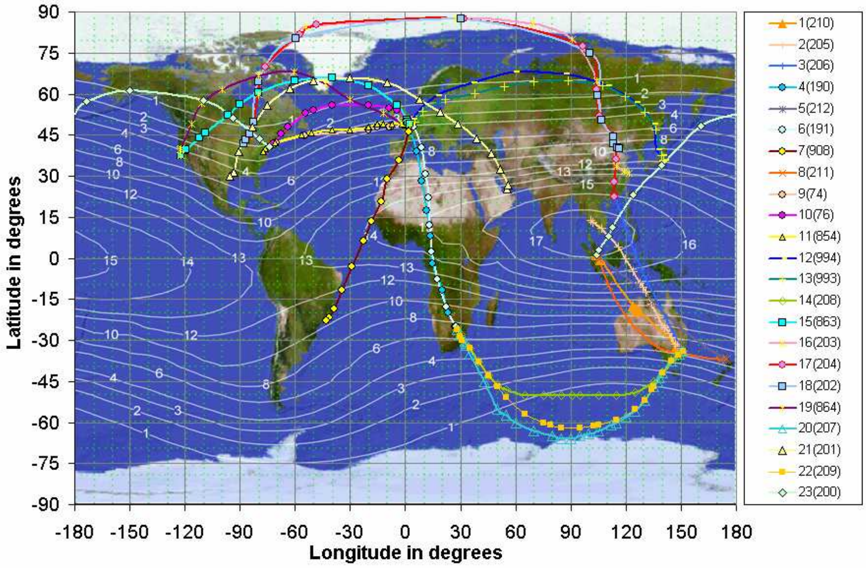
Flight data format

Flight Num; Dep airport; Arr airport; Dep date; Dep UT; Arr date; Arr UT;
Flight Num; Way point; Flight Level; Time from departure; latitude; longitude;

00074;LFPG;KJFK;12/09/2007;01:00;12/09/2007;08:19;
00074;AER;000;00:00;490036N;0023254E;
00074;TOC;340;00:23;484930N;0000048W;
00074;INT;360;00:24;485018N;0001500W;
00074;INT;370;01:08;480000N;0080000W;
00074;INT;360;01:12;480000N;0084500W;
00074;INT;350;01:45;480000N;0150000W;
00074;INT;370;02:10;470000N;0200000W;
00074;INT;380;05:08;443612N;0545300W;
00074;INT;390;06:46;420236N;0702530W;
00074;TOD;390;06:54;413354N;0713630W;
00074;AER;000;07:19;403812N;0734606W;

Code	Airport	Code	Airport
LFPG	Paris	OMDB	Dubai
KJFK	New York	KIAH	Houston
KIAD	Washington	KORD	Chicago
KSFO	San Francisco	ZBAA	Beijing
SBGL	Rio de Janairo	ZSPD	Shanghai
RJAA	Tokyo	VHHH	Hong Kong
FAJS	Johannesburg	VTBD	Bangkok
WSSS	Singapore	YSSY	Sydney
KEWR	Newark	NZAA	Auckland

Route map



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Comparison of the dose received during the different flights

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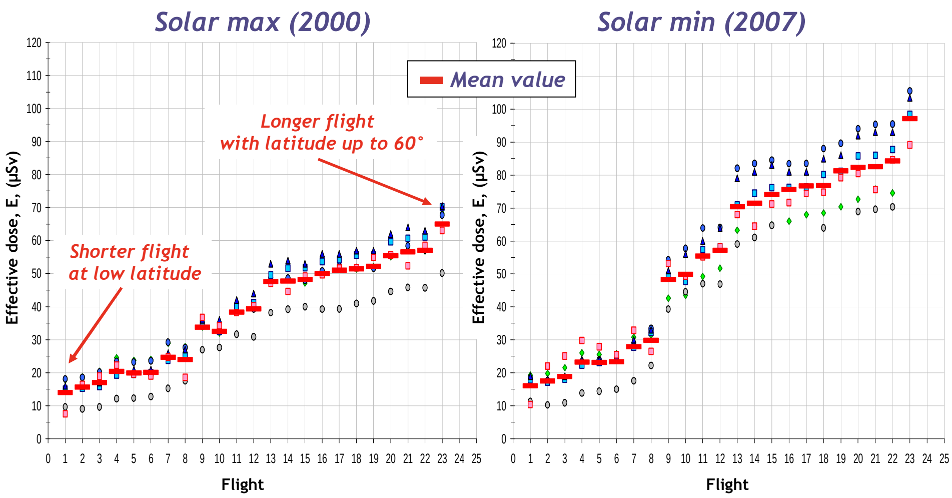
Effective dose (E) per flight



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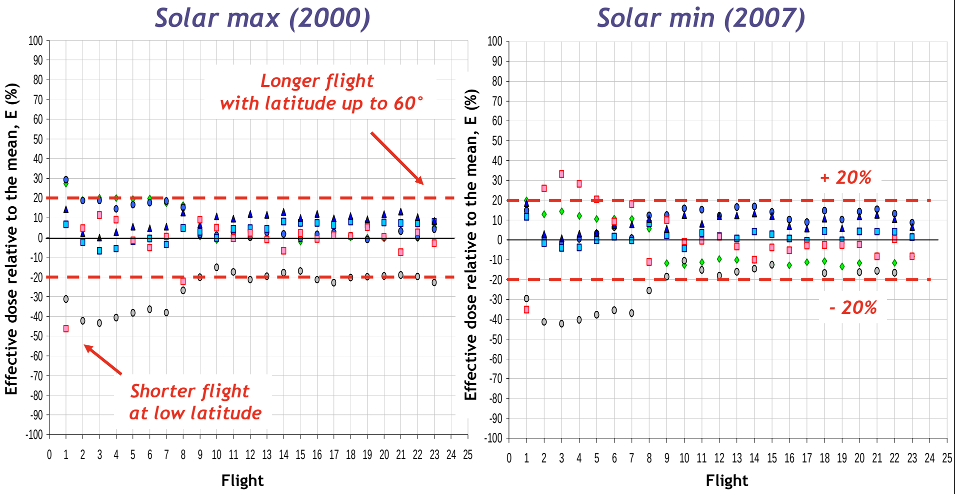
Effective dose (E) relative to the mean value



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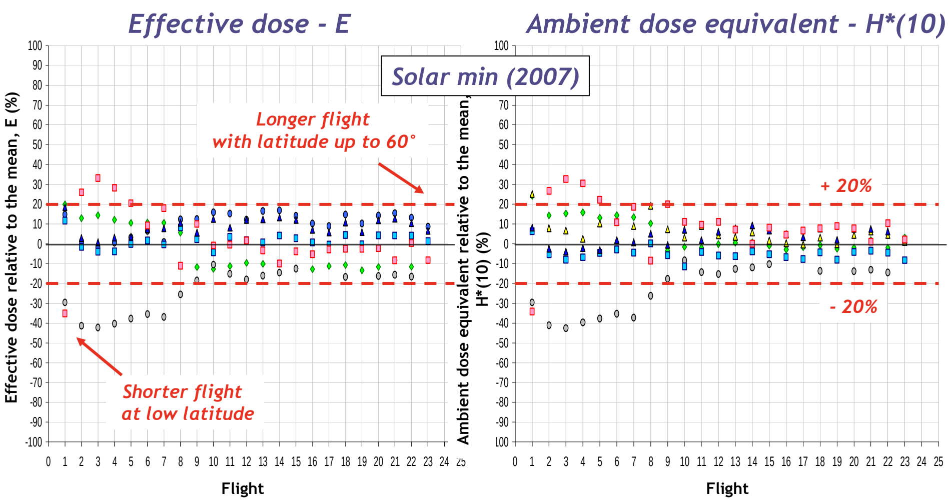
E and H*(10) relative to the mean value



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Data analysis for a single flight

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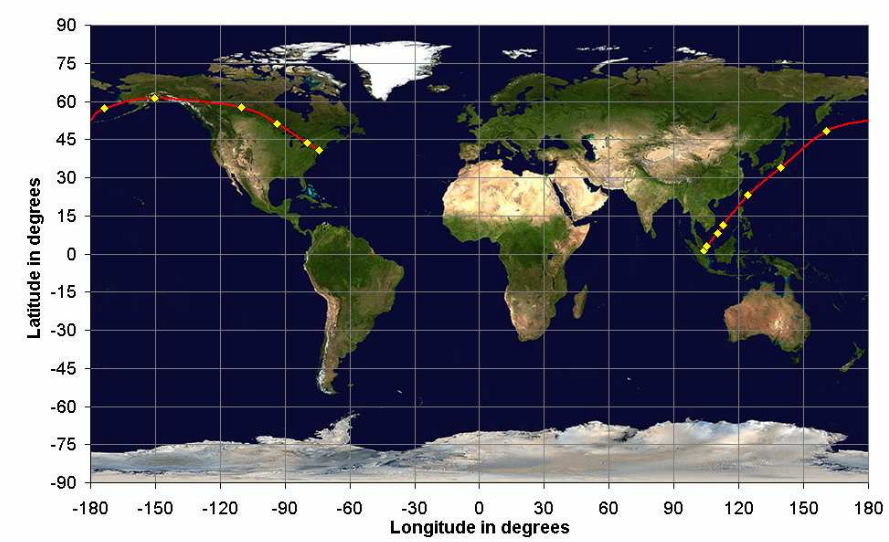
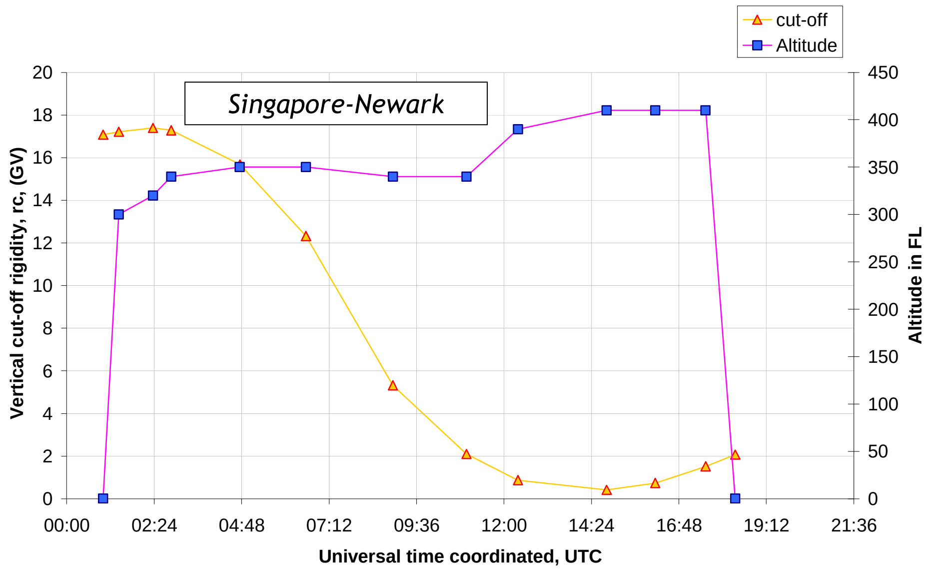
Single flight analysis - *Singapore-Newark*

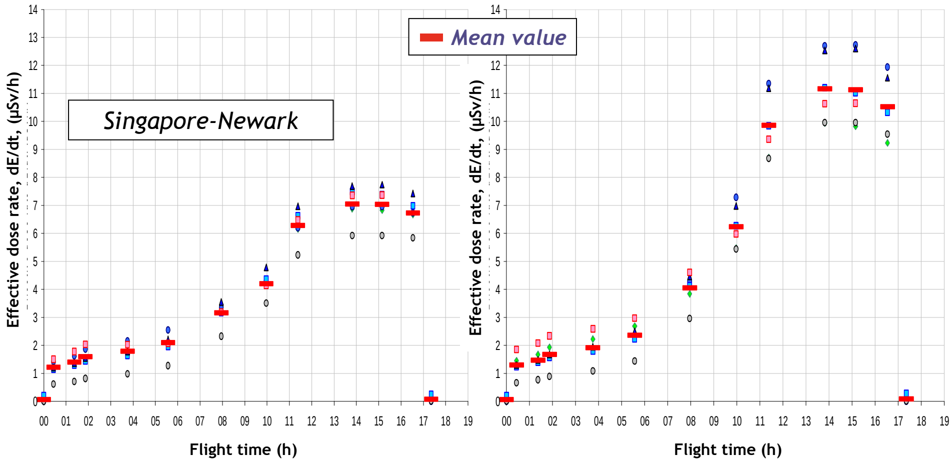


Altitude and rigidity profiles



Effective dose rate profile

Solar max (2000) *Solar min (2007)*



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Analysis of dose rate vs. cut-off rigidity and altitude

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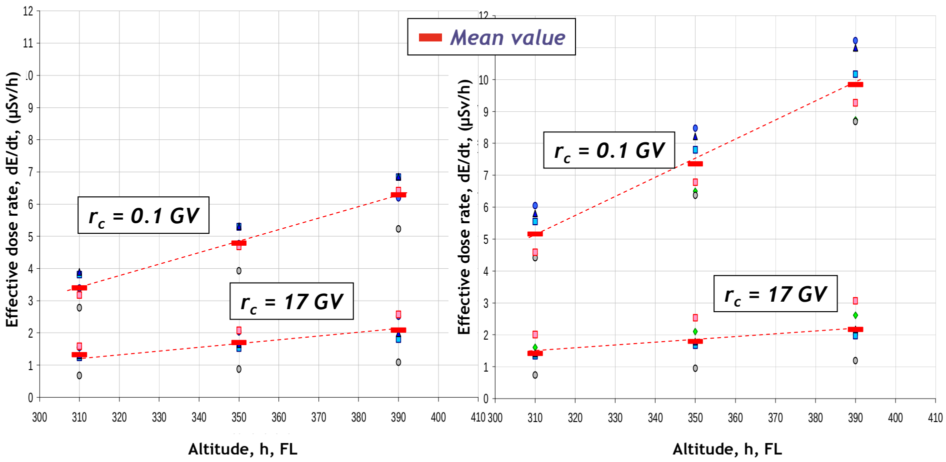
Effective dose rate vs. altitude

Solar max (2000) *Solar min (2007)*



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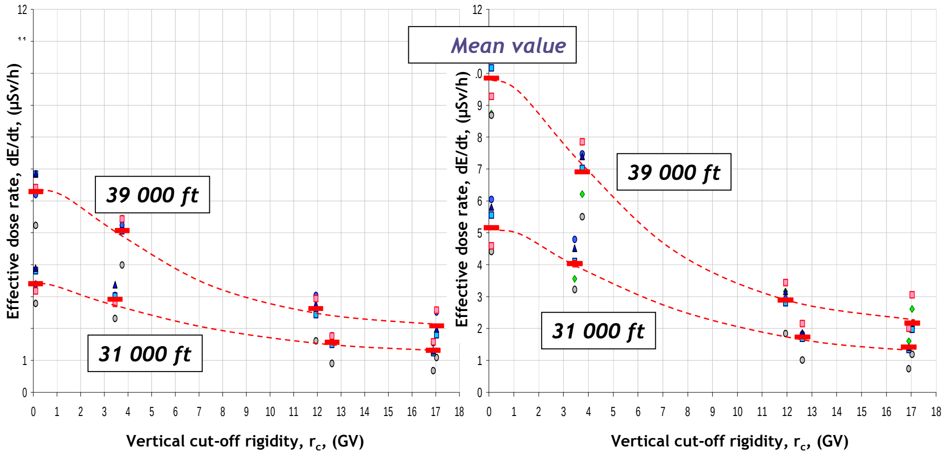
Effective dose rate vs. cut-off rigidity

Solar max (2000) Solar min (2007)



Summary and conclusion

- **7 codes** have been compared, some of them are based on analytical or Monte Carlo calculations and other ones on experimental data
- One code deviates by about +30% the mean value at low latitude for solar min activity
- Another code deviates by around -40% the mean value at low latitude
- The agreement **within 20%** for most of the codes, especially those used routinely for aircraft crew dosimetry, compared to the mean value can be considered as **fully satisfactory for radiation protection purposes**

Contributors

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Be confident, the dose assessment onboard aircraft is under control!