



ECA

European Cockpit Association

Space Weather :

the view from the cockpit

Cpt. Klaus Sievers
European Cockpit Association

03/2013

Concept of Operations
(ConOps)
for
International
Space Weather Information
in
Support of Aviation



3 November 2011

Mr. Raul Romero
(IAWOPSG Secretary
International Civil Aviation Organization)

Dear Raul Romero:

At the last IAWOPSG meeting which was held at the Western and Central Africa Regional offices in Dakar, the group agreed on Conclusion 021 about the Development of Operational requirements for space weather products. The conclusion stated that:

a) IATA be invited to develop a high-level user requirement for space weather and provide this to the Secretary by 1 November 2011;

(.....)
Impacts of Space Weather to Commercial Aviation:

- In addition to the impact on global navigation satellite systems, Space Weather adversely affects HF communications, increases total radiation levels in humans, and impedes aircraft surveillance. Therefore, access to timely, impact-based information about Space Weather is an operational requirement and it will have a growing importance as future technology evolves.

June 2011

Version 1



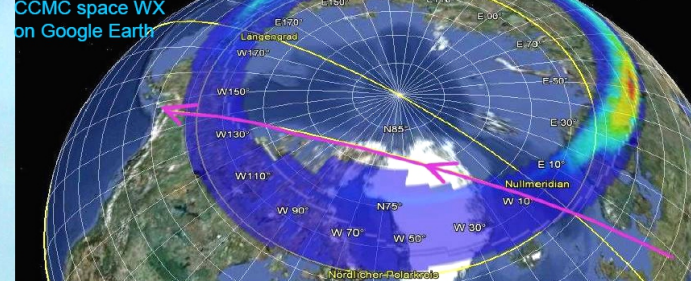
December 2012

Version 2.2

Therefore, provision of Space Weather information is considered an operational requirement.

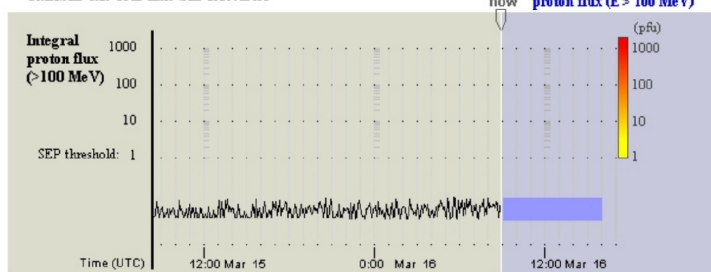
Communication - Navigation - Avionics - radiation dose for Humans

CONCEPT OF OPERATIONS
(CONOPS)
FOR
SPACE WEATHER INFORMATION
IN
SUPPORT OF INTERNATIONAL AIR
NAVIGATION

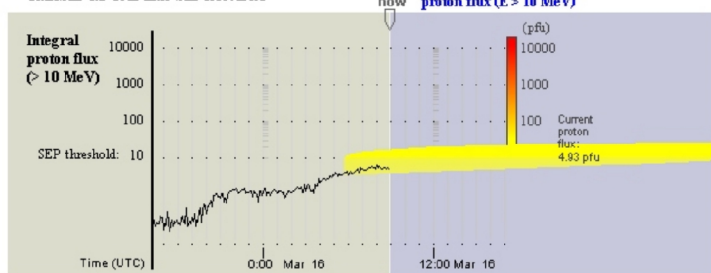


20 years ago, I just enjoyed the view.

UMASEP 1.2. real-time SEP forecaster



UMASEP 1.2. real-time SEP forecaster



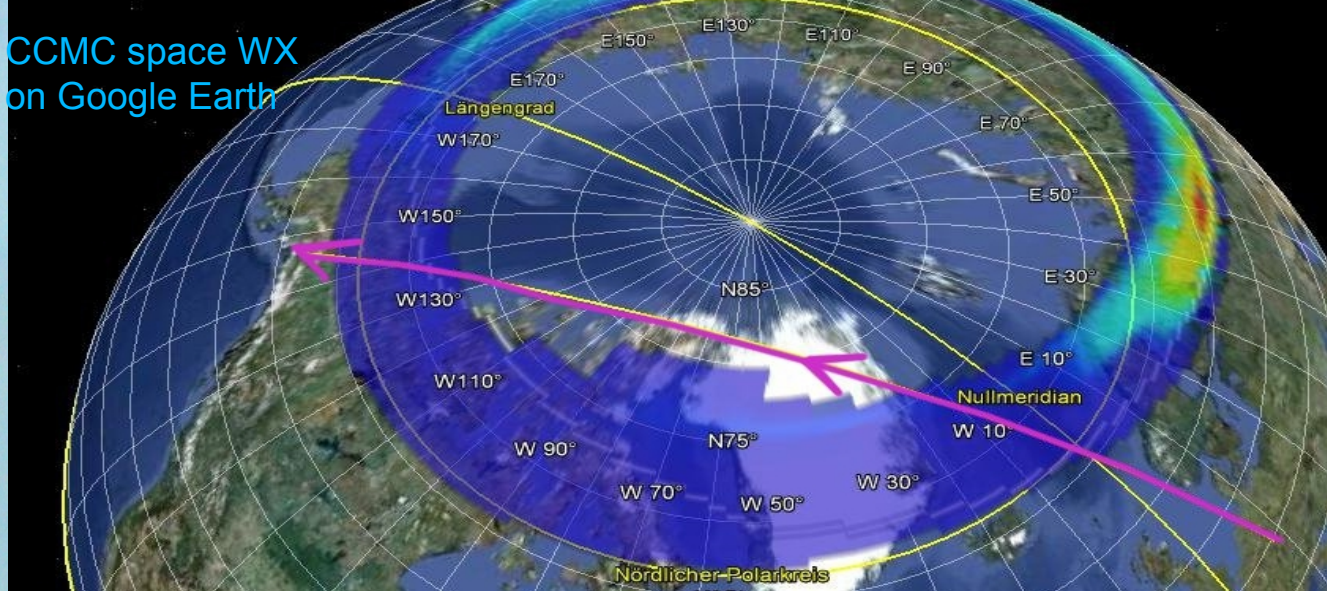
ECA

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What do pilots need ?

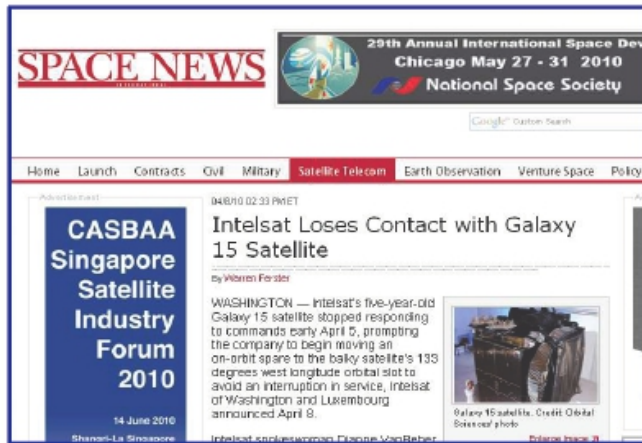
- * accurate and reliable space weather and cosmic radiation forecasting
- * forecasts, measurements and warnings in standardized form, for the whole flight
- * continuous measurements of Space Weather, so warnings can be given with high priority when threshold levels of radiation, communication and navigation disturbance are exceeded.
- * distribution of forecasts, measurements and warnings analogous to the present ICAO / WMO weather and sigmet system.
- * Space Weather training for pilots, dispatchers and air traffic controllers

CCMC space WX
on Google Earth



20 years ago, I just enjoyed the view.



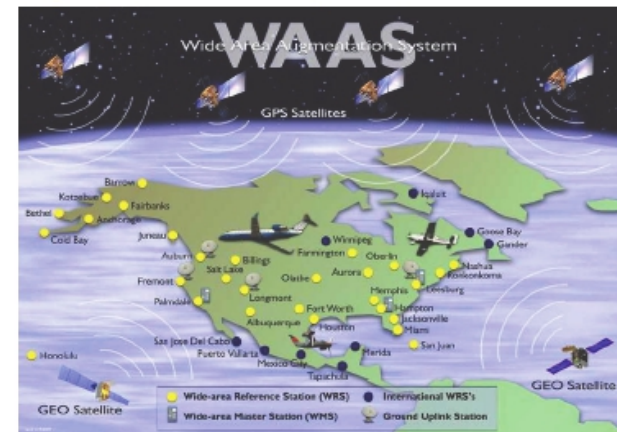


08 Apr 2010 – Intelsat reports that the Galaxy 15 stopped responding to ground commands (Anomaly time: 05 April @ 09:48 UTC)

10 Apr 2010 – FAA predicts erosion of WAAS capability due to Galaxy 15 failure

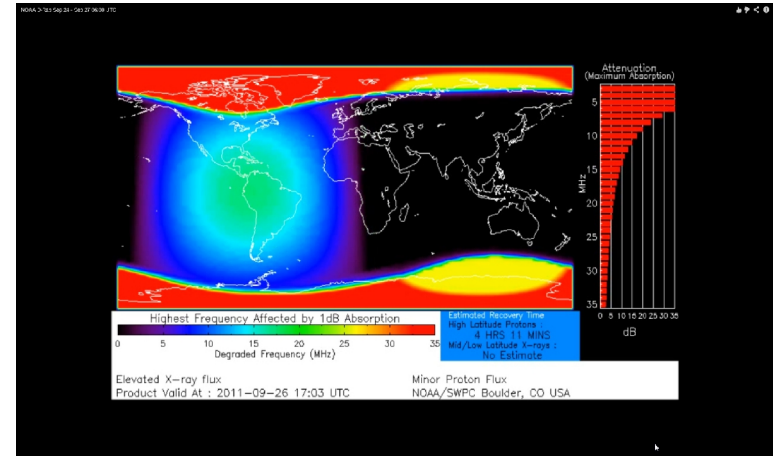
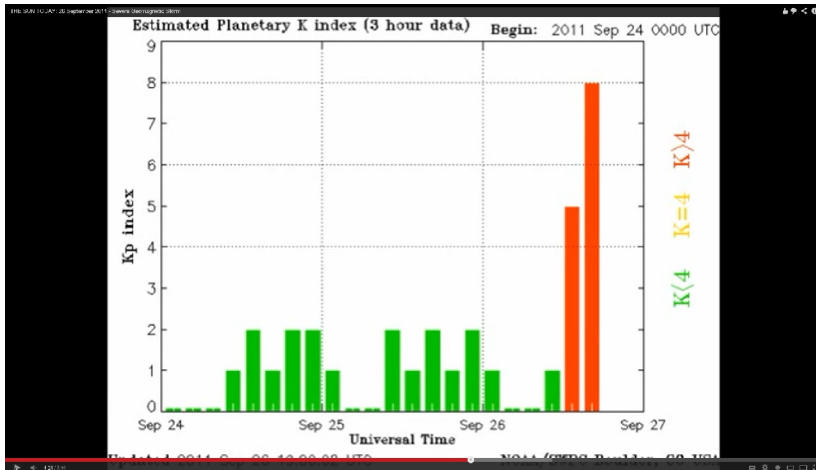
20 Apr 2010 – Orbital attributes the loss of Galaxy 15 to space weather

30 Apr 2010 – Intel reports Galaxy 15 still adrift and threatens nearby satellites (i.e. frequency interference)



Navigation: how does aviation deal with failure of EGNOS / WAAS satellites due to Space Weather ?

Sept. 26 / 27, 2011: WAAS CAT 1 approaches u/s



SWPC: Issue Time: 2011 Sep 26 1708 UTC

WARNING: Geomagnetic K-index of 7 or greater expected

Valid From: 2011 Sep 26 1715 UTC Valid To: 2011 Sep 26 2100 UTC

Warning Condition: Onset NOAA Scale: G3 or greater - Strong to Extreme

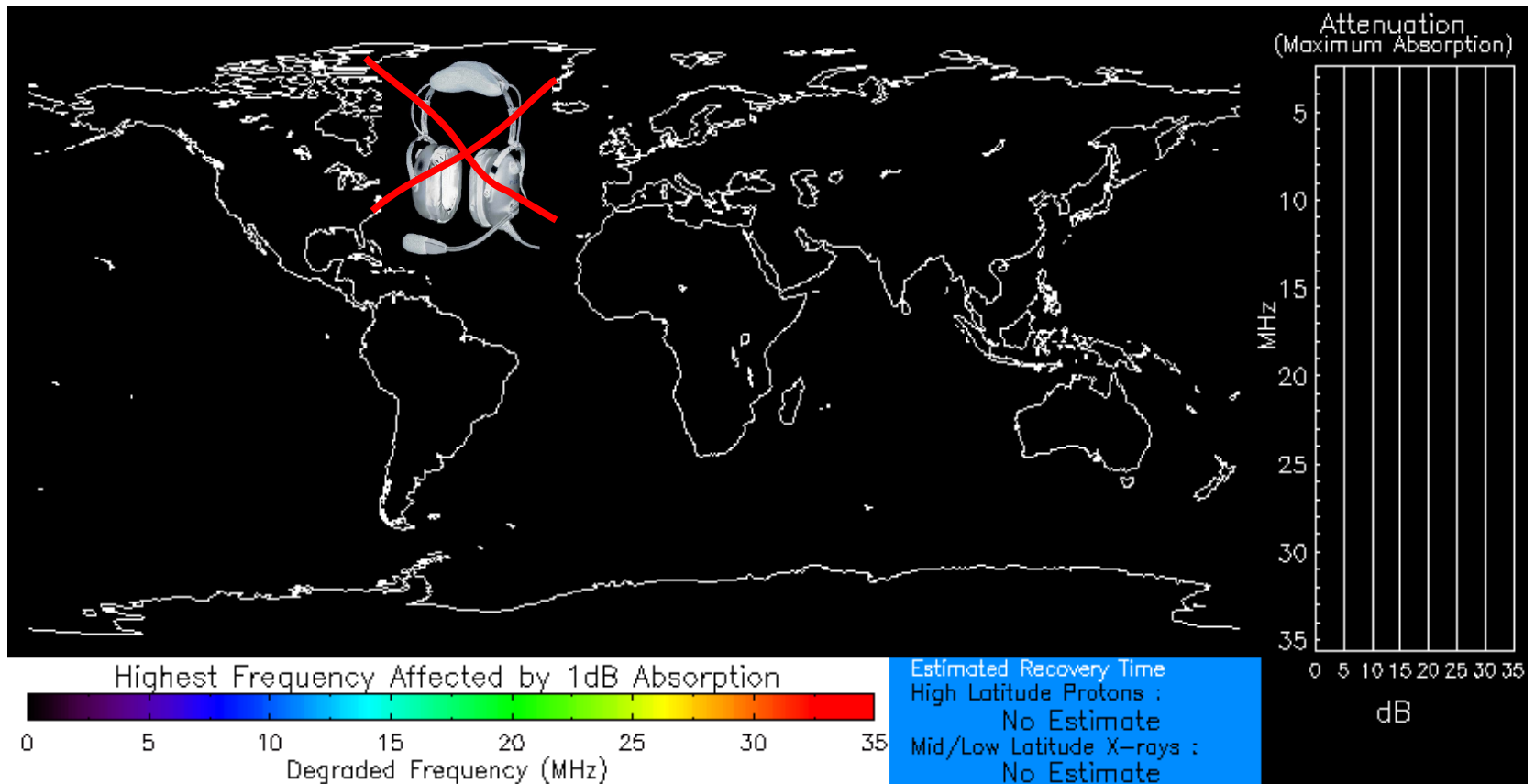
Air Traffic Control System Command Center (‘‘Network Manager’’):

ATCSCC ADVZY 059 DCC 09/XX/2011 WAAS FYI

DUE TO SOLAR FLARE ACTIVITY; WAAS SIGNALS ARE DEEMED UNRELIABLE:
AS A RESULT; RNP CAT 1 ARRIVAL PROCEDURES WITHIN THE U.S. ARE ALSO
DEEMED UNRELIABLE. 261930 – 271059 11/09/XX 20:30 DCCOPS

Not quite a NOTAM, but close.

A colleague reported extremely strong aurora, **weak / no HF** conditions and even **disturbance of VHF (!)** while flying east-bound over Gander, Canada on Aug. 27, 00 – 03z, 2012.



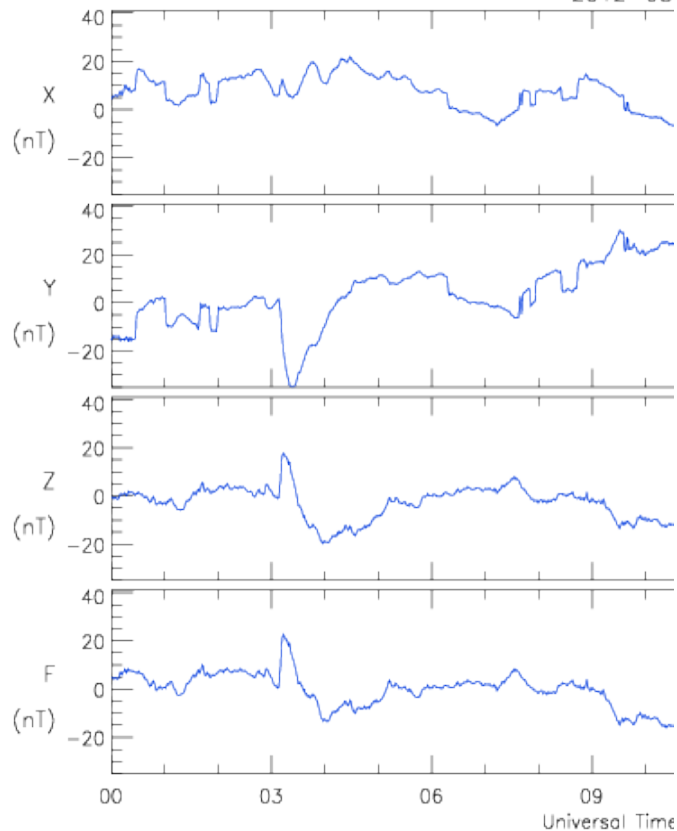
Normal X-ray Background
Product Valid At : 2012-08-27 02:12 UTC

Normal Proton Background
NOAA/SWPC Boulder, CO USA

**Normal shortwave communication indicated in theory,
but almost impossible in reality !**

St Johns (STJ) based on 1-minute variation data

2012-08-27



Natural Resources Canada
Ressources naturelles Canada

**Location of magnetometer
& of aircraft**

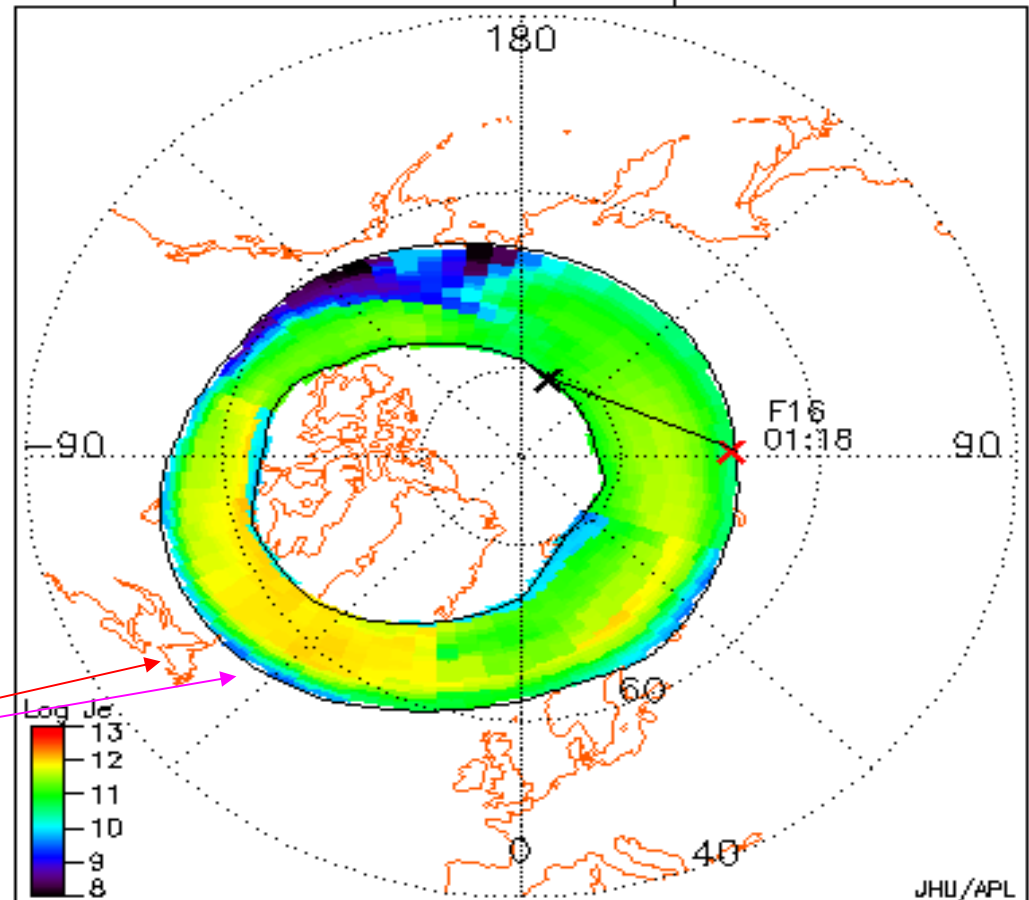
**Magnetic field disturbed
and strong aurora
measured by satellite !**

NORTH CAP

End Time 27 Aug 2012 — 01:30

DMSP Satellite : F16

No UVI Data for this period.



Normalized B₂₁ = 63 Flux = 553 MWb
Equivalent K_p = 2.7 Global e⁻ E-Flux = 19.3 MW

13MEDBL01

12 November 2012



- ✍ Flight personnel with an effective dose of more than 1 mSv/y should be recognised as occupationally exposed to ionizing radiation. Those who are liable to receive an effective dose greater than 6 mSv per year should be classified as Category A workers.
- ✍ All aircraft with a maximum operating altitude of more than 8,000m (approx. 26,000ft) operating in polar/sub polar regions, especially long-range aircraft, should be equipped with a warning device to detect sudden increases in dose rate. During flight, the cockpit crew should have the display of the warning function plainly visible to allow timely response to suddenly increased levels of dose rates.
- ✍ IFALPA recommends that an ICAO sponsored multi-party task force be formed to address all issues associated with an ionizing radiation event and the possible subsequent emergency descent of a large number of aircraft.

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3 November 2011

Mr. Raul Romero
IAVWOPSG Secretary
International Civil Aviation Organization

Dear Raul Romero

At the last IAVWOPSG/6 meeting which was held at the Western and Central Africa Regional offices in Dakar, the group agreed on Conclusion 6/31 about the Development of Operational requirements for space weather products. The conclusion stated that;

a) IATA be invited to develop a high-level user requirement for space weather and provide this to the Secretary by 1 November 2011;

(.....)

Impacts of Space Weather to Commercial Aviation:

- In addition to the impact on global navigation satellite systems, Space Weather adversely affects HF communications, increases solar radiation levels in humans, and impedes aircraft surveillance. Therefore, access to timely, impact-based information about Space Weather is an operational requirement and it will have a growing importance as future technology evolves.

(.....)

Therefore, provision of Space Weather information is considered an operational requirement.



June 2011

Version 1

December 2012

Version 2.2

Communication - Navigation - Avionics - radiation dose for Humans



International Civil Aviation Organization

IAVWOPSG/7-WP/20
30/1/13

WORKING PAPER

INTERNATIONAL AIRWAYS VOLCANO WATCH OPERATIONS GROUP (IAVWOPSG)

SEVENTH MEETING

Bangkok, Thailand, 18 to 22 March 2013

Agenda Item 8: Matters related to the assessment of the need to provide information on solar radiation storms and other bio-hazards

FOLLOW-UP ON CONCLUSION 6/31 D) — STANDARDS AND RECOMMENDED PRACTICES FOR SPACE WEATHER INFORMATION

(Presented by Australia, New Zealand, the United States and IATA)

SUMMARY

This working paper presents a proposal for amendment of Annex 3 related to space weather information. Action by the IAVWOPSG is in paragraph 4.



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What do pilots need ?

- * accurate and reliable space weather and cosmic radiation forecasting
- * forecasts, measurements and warnings in standardized form, for the whole flight
- * continuous measurements of Space Weather, so warnings can be given with high priority when threshold levels of radiation, communication and navigation disturbance are exceeded.
- * distribution of forecasts , measurements and warnings analogous to the present ICAO / WMO weather and sigmet system.
- * Space Weather training for pilots, dispatchers and air traffic controllers

fuel and time weather reports notams
aircraft technical condition

weather charts

30 to 60 pages...and 15 minutes time
to read, evaluate, decide

from Belgium :

:Issued: 2012 Oct 23 0827 UTC

:Product: documentation at <http://www.sidc.be/products/presto>

#-----#

FAST WARNING 'PRESTO' MESSAGE from the SIDC (RWC-Belgium)

#-----#

NOAA Active Region 1598 produced an M5.0 flare on Oct 22, peaking at 18:51UT and an X1.8 flare on Oct 23, peaking at 03:17UT. There is a time gap for SOHO/LASCO images between Oct 22, 20:36UT and Oct 23, 06:00UT. STEREO A/COR2 images are missing between Oct 22, 15:24UT and Oct 23, 03:54UT, STEREO B/COR2 images are missing from Oct 22, 16:55UT. There is no coronagraphic evidence for an associated plasma eruption before 20:36UT. The proton fluxes did not increase.

#-----#

Solar Influences Data analysis Center - RWC Belgium

Royal Observatory of Belgium

Fax : 32 (0) 2 373 0 224

Tel.: 32 (0) 2 373 0 491

#

For more information, see <http://www.sidc.be>. Please do not reply

directly to this message, but send comments and suggestions to

'sidctech@oma.be'. If you are unable to use that address, use

'rvdlinden@spd.aas.org' instead.

To unsubscribe, visit <http://sidc.be/registration/unsub.php>

#-----#

Available: warning, yes, but too long and complicated.

from the USA:

Space Weather Message Code: ALTXMF
Serial Number: 182
Issue Time: 2012 Oct 22 1852 UTC

ALERT: X-Ray Flux exceeded M5
Threshold Reached: 2012 Oct 22 1851 UTC
NOAA Scale: R2 - Moderate

NOAA Space Weather Scale descriptions can be found at
www.swpc.noaa.gov/NOAAscales

Potential Impacts: Area of impact centered on sub-solar point on the sunlit side of Earth. Extent of blackout of HF (high frequency) radio communication dependent upon current X-ray Flux intensity. For real-time information on affected area and expected duration please see <http://www.swpc.noaa.gov/drap/index.html>.

Thank you for using the Product Subscription Service. If you would like to remove a product subscription or update the personal information in your account, go to the Please do not use the from address for correspondence, as it is not monitored. For comments or help, please contact

[SWPC Help](#)

Available: warning, yes, but too long and complicated.

SUBJ: IPS GEOMAGNETIC DISTURBANCE WARNING
12/10
ISSUED AT 05/2328Z JULY 2012
BY THE AUSTRALIAN SPACE FORECAST CENTRE.

**INCREASED GEOMAGNETIC ACTIVITY EXPECTED
FROM 06-08 JULY 2012**

GEOMAGNETIC ACTIVITY FORECAST

06 Jul: Quiet to Unsettled

07 Jul: Quiet to unsettled. Active to minor storm periods possible late.

08 Jul: Unsettled to active. Isolated minor storm periods likely.

IPS Radio and Space Services email: asfc@ips.gov.au
PO Box 1386 WWW: <http://www.ips.gov.au>
Haymarket NSW 1240 AUSTRALIA FTP: <ftp://ftp.ips.gov.au>
tel: +61 2 9213 8010 fax: +61 2 9213 8060

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and delete all copies of this e-mail and attachments.
To unsubscribe from an IPS mail list either send an email to
"MAIL_LIST"-leave@ips.gov.au or go to
http://www.ips.gov.au/mailman/listinfo/MAIL_LIST.
Information about training can be obtained from
<http://www.ips.gov.au/mailman/listinfo/ips-training>.
General information is available from
<http://www.ips.gov.au/mailman/listinfo/ips-info>.

from Australia:

**Available:
warning, yes,
but too long and
complicated.**

FAA

Solar Radiation Alert System

Halloween-Storm 2003

Space Weather Message Code: ALTPAV
Serial Number: 862
Issue Time: 2003 Oct 29 2128 UTC

UPDATE ALERT: Altitude Update for Solar Radiation Alert
Alert Conditions Began: 2003 Oct 29 2105 UTC

Comment:

A solar proton event in progress may lead to excessive radiation doses to air travelers at Corrected Geomagnetic Latitudes above 35 degrees north or south.

See map at <http://www.cami.jccbi.gov/radiation.html>

See article at http://www.usatoday.com/weather/news...ar-storm_x.htm

Current recommended maximum flight altitude: 25 000 feet.

Solar radiation Altitude effective dose rate (feet) (millisieverts/hour) *

20 000 >0.0049
30 000 >0.023
40 000 >0.062
50 000 >0.11

* Estimates for high-latitude locations. Dose rates are based on near real-time GOES satellite measurements and are recalculated every three minutes.

Radiation : Alert message for aviation.
Distribution of message: SpaceWX Center

This is not a Sigmet – but close.



Northern Hemisphere Dose

Global Dose

Selected Flight Path Dose

Geomagnetic Cutoff Rigidity

Effective Dose Rate¹(E) for 2012-09-03 11:00-12:00 GMT

5km (16,000 feet) Radiative Dose Rate (uSv/hr)								
lat	90S-60S	60S-40S	40S-20S	20S-0	0-20N	20N-40N	40N-60N	60-90N
avg	3.09	2.47	1.41	0.64	0.55	1.02	2.12	2.66
max	3.39	3.36	2.76	1.23	1.35	2.27	2.77	2.92

11km (35,000 feet) Radiative Dose Rate (uSv/hr)								
lat	90S-60S	60S-40S	40S-20S	20S-0	0-20N	20N-40N	40N-60N	60-90N
avg	11.79	8.98	4.28	1.52	1.29	2.90	7.77	10.61
max	12.40	12.27	10.18	3.44	3.93	8.64	10.77	11.03

15km (49,000 feet) Radiative Dose Rate (uSv/hr)								
lat	90S-60S	60S-40S	40S-20S	20S-0	0-20N	20N-40N	40N-60N	60-90N
avg	17.16	12.41	5.34	1.74	1.47	3.58	10.94	15.81
max	18.14	17.67	14.20	4.20	4.85	12.82	15.86	16.14

Representative High-Latitude Flights

2012-09-03 11:00-12:00 GMT

Flight Name	Time hours	Rate ¹ uSv/hr	Dose ¹ mSv	Safety Signal		
				Aircrew ²	Public ³	Prenatal ⁴
London,GBR - New York,USA	5.50	9.47	0.052			
Chicago,USA - Stockholm,SWE	8.50	10.29	0.087			
Chicago,USA - Munich,DEU	8.50	9.64	0.082			
Chicago,USA - Beijing,CHN	13.50	9.67	0.131			

Signal	Aircrew ⁵ Max_Annual(800hrs)	Public ⁶ one_trip	Prenatal ⁶ one_trip
	0-6.0mSv	0-0.330mSv	0-0.167mSv
	6.0-12.0mSv	0.330-0.670mSv	0.167-0.333mSv
	>12.0mSv	>0.670mSv	>0.333mSv

0. ICRP: International Commission on Radiological Protection

1. Real-time radiation exposure is computed as an effective dose rate, which is a body-average over the radiative-sensitive organs and tissues, in units of microsievert per hour (uSv/hr). Annual or flight accumulated effective dose is reported in units of millisievert (mSv; Note: 1 mSv = 1000 uSv).

2. ICRP recommended annual limit for occupationally exposed radiation workers (including aircrew) is less than 20 mSv. If the predicted exposure is less than 1/3 of this limit, the safety signal color will be green - indicating minimal radiation exposure. If the predicted exposure is between 1/3-2/3 of the ICRP recommended limit, the safety signal color will be yellow - indicating that close tracking of individual radiation exposure is advised. If the predicted exposure is greater than 2/3 the recommended limit, the safety signal color will be red - indicating exposure to maximum recommended limit is possible.

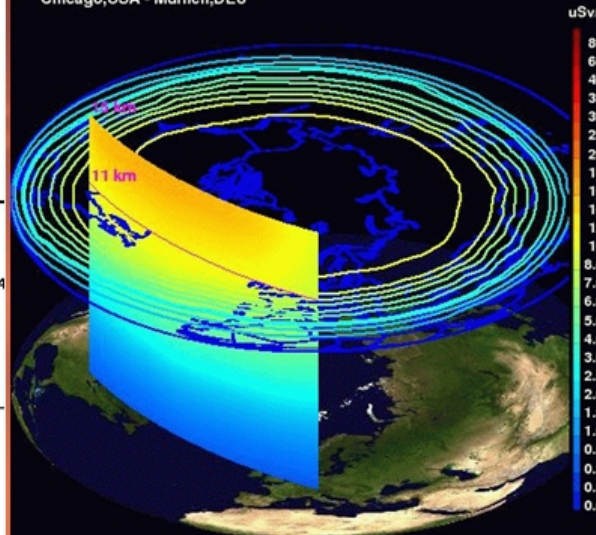
3. ICRP recommended annual limit for public sector radiation exposure is less than 1 mSv. If the predicted exposure is less than 1/3 of this limit, the safety signal color will be green - indicating minimal radiation exposure. If the predicted exposure is between 1/3-2/3 of the ICRP recommended limit, the safety signal color will be yellow - indicating that close tracking of individual radiation exposure is advised. If the predicted exposure is greater than 2/3 the recommended limit, the safety signal color will be red - indicating exposure to maximum recommended limit is possible.

4. ICRP recommended limit for prenatal radiation exposure is less than 1 mSv annually and less than 0.5 mSv in any one month during pregnancy. The signal indicator color is based on the 0.5 mSv limit. If the predicted exposure is less than 1/3 of this limit, the safety signal color will be green - indicating minimal radiation exposure. If the predicted exposure is between 1/3-2/3 of the ICRP recommended limit, the safety signal color will be yellow indicating that close tracking of individual radiation exposure is advised. If the predicted exposure is greater than 2/3 the recommended limit, the safety signal color will be red - indicating exposure to maximum recommended limit is possible.

Representative flight paths: Altitudes and viewing perspective

Effective Dose Rate(E) for 2012-09-03 11:00-12:00 GMT

Chicago,USA - Munich,DEU



Static View

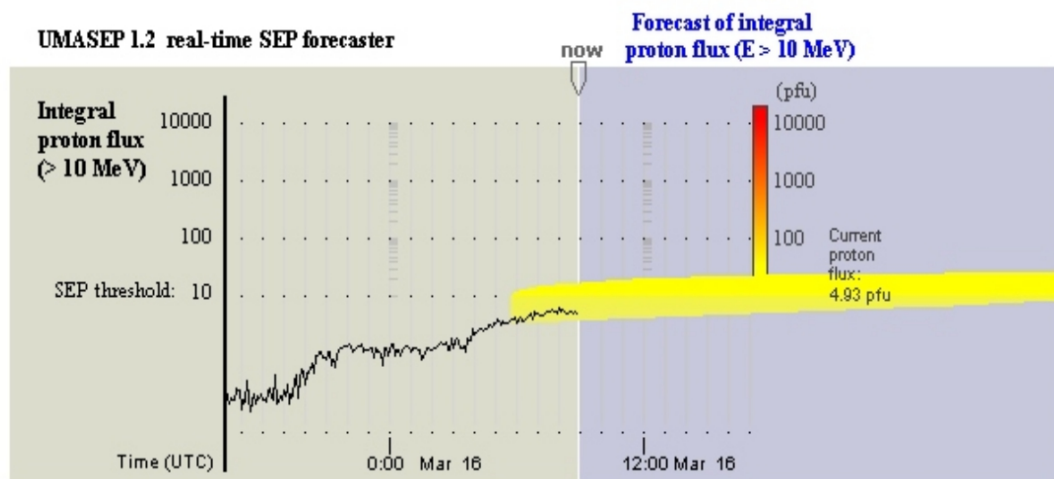
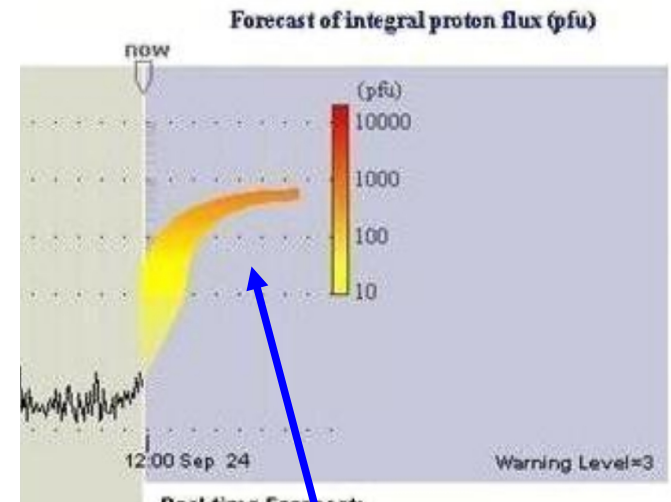
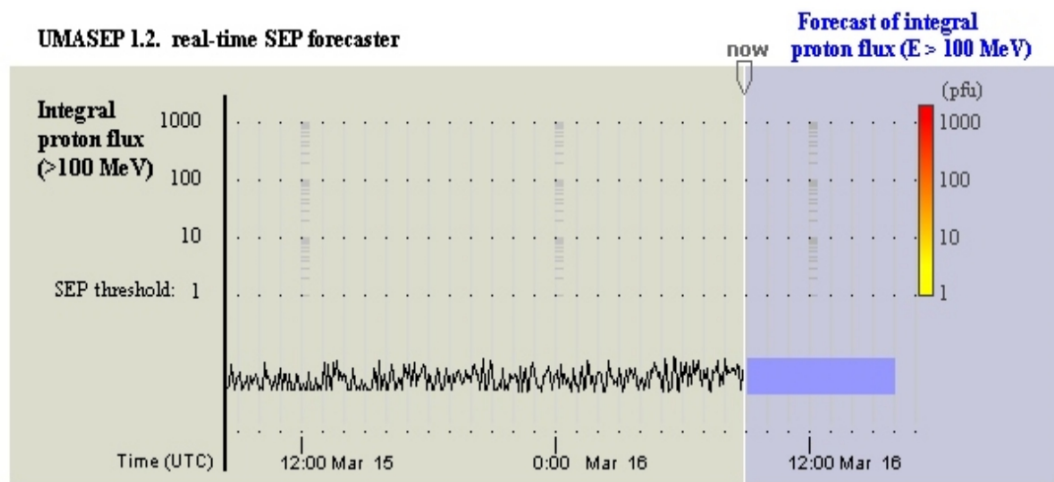
NewYork,USA-
London,GBR
Chicago,USA-
Stockholm,SWE
Chicago,USA-
Munich,DEU
Chicago,USA-
Beijing,CHN

Dynamic View

NewYork,USA-
London,GBR
Chicago,USA-
Stockholm,SWE
Chicago,USA-
Munich,DEU
Chicago,USA-
Beijing,CHN

Example
of
radiation
intensity
depiction
with
hight +
track
info

Radiation dose: NAIRAS gives accurate real-time information-
regretfully, no forecast.



Examples of forecast SEP-event

Space Weather Message Code: ALTPX1
Serial Number: 298
Issue Time: 2013 Mar 16 1958 UTC

ALERT: Proton Event 10MeV Integral Flux exceeded 10pfu
Begin Time: 2013 Mar 16 1940 UTC
NOAA Scale: S1 - Minor
Potential Impacts: Radio - Minor impacts on polar HF (high fre

SEP-forecasting tool of Univ. of Malaga:
achieved 13 hrs for 'lower' energetic particle event 16 March 2013
reliable forecast time is avg. 30 min. for high energy events.

Space Weather for Aviation Service Providers

NOAA National Weather Service Space Weather Prediction Center

24 hour Forecast issued Oct 01 0300 UTC, Geophysical Alert Message

Solar-terrestrial indices for 30 September follow.
Solar flux 136 and estimated planetary A-index 10.
The estimated planetary K-index at 0300 UTC on 01 October was 7.

Space weather for the past 24 hours has been strong.
Geomagnetic storms reaching the G3 level occurred.
Radio blackouts reaching the R1 level occurred.

Space weather for the next 24 hours is predicted to be strong.
Geomagnetic storms reaching the G3 level are expected.

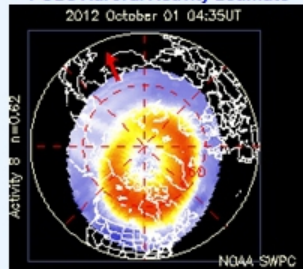
Latest 3-day Solar Weather Forecast

Info is nice to know, good to have, but what action is expected ?

NOAA Scales Activity

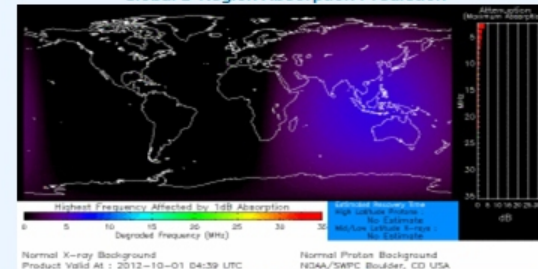
NOAA Scale	Past 24 hours	Current
Geomagnetic Storms	G3	G3
Solar Radiation Storms	none	none
Radio Blackouts	none	none

POES Auroral Activity Estimate



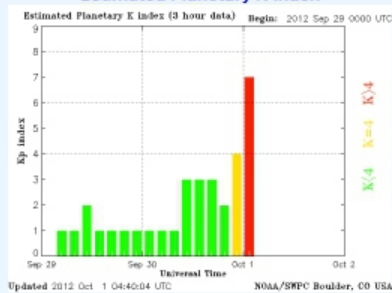
Effects: HF Radio propagation, Aurora boundaries

Global D-Region Absorption Prediction

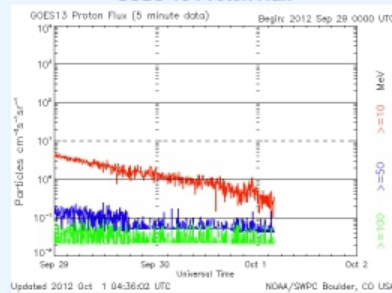


Effects: HF Radio communications

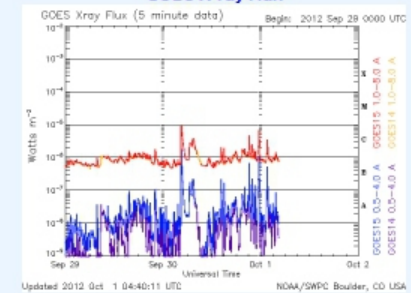
Estimated Planetary K-index



GOES-15 Proton Flux



GOES X-ray Flux



Website made for aviation: Information use needs to be defined.

low levels are 5 minute averages. Flux in particles $\text{cm}^{-2} \text{ster}^{-1} \text{cm}^{-2} \text{sec}^{-1}$ Bas

G 4	Severe	<p>Power systems: possible widespread failure; spacecraft will mistakenly trip out key assets from power system.</p> <p>Spacecraft operations: may experience problems with orientation problems.</p> <p>Other systems: induced pipeline magnetic field may degrade satellite navigation; a degraded satellite has been seen as low as Alaska lat.)**.</p>
G 3	Strong	<p>Power systems: voltage corrections to devices.</p> <p>Spacecraft operations: surface charging on low-Earth-orbit satellites, and on the ground.</p> <p>Other systems: interminant satellite may occur; HF radio may be intermittent; Oregon (typically 50° geomagnetic lat.)</p>
G 2	Moderate	<p>Power systems: high-latitude power storms may cause transformer damage.</p> <p>Spacecraft operations: corrective actions possible; changes in drag affect orbit.</p> <p>Other systems: HF radio propagation low as New York and Idaho (typically 40° geomagnetic lat.)</p>
G 1	Minor	<p>Power systems: weak power grid fluctuations.</p> <p>Spacecraft operations: minor impacts.</p> <p>Other systems: migratory animals are visible at high latitudes (northern Michigan).</p>

Int. levels are 5 minute averages. Flux in particles $\cdot \text{cm}^{-2} \cdot \text{ster}^{-1} \cdot \text{cm}^{-2}$ R₂₆

Flux, measured in the 0.1-0.8 nm range, in W m^{-2} . Based on this measure, but other physical measures are also considered.
 * Other frequencies may also be affected by these conditions.

Meaning needs clearer definition for aviation

Excerpt from NOAA space weather scale for Geomagnetic Storm

G 4	Severe	<p>Power systems: possible widespread voltage control problems and some protective systems will mistakenly trip out key assets from the grid.</p> <p>Spacecraft operations: may experience surface charging and tracking problems, corrections may be needed for orientation problems.</p> <p>Other systems: induced pipeline currents affect preventive measures, HF radio propagation sporadic, satellite navigation degraded for hours, low-frequency radio navigation disrupted, and aurora has been seen as low as Alabama and northern California (typically 45° geomagnetic lat.)**.</p>
G 3	Strong	<p>Power systems: voltage corrections may be required, false alarms triggered on some protection devices.</p> <p>Spacecraft operations: surface charging may occur on satellite components, drag may increase on low-Earth-orbit satellites, and corrections may be needed for orientation problems.</p> <p>Other systems: intermittent satellite navigation and low-frequency radio navigation problems may occur, HF radio may be intermittent, and aurora has been seen as low as Illinois and Oregon (typically 50° geomagnetic lat.)**.</p>

Navigation: Can I, as a pilot, depend on using satellite-navigation for approach and landing ?

G3: intermittent satellite navigation

G4: satellite navigation degraded for hours

SOLAR FLARES NEWSLETTER

Sehr geehrte Kolleginnen und Kollegen,

am gestrigen 15.03. hat sich auf der Sonne ein koronaler Massenauswurf der Klasse M1 ereignet.

Aus strahlenschutztechnischer Sicht hat dieser keine besondere Relevanz.

Fliegerisch könnte sich der geomagnetische Sturm heute und morgen jedoch durch HF-Störungen und Polarlichter sowie möglicherweise Satellitensignalstörungen bemerkbar machen.

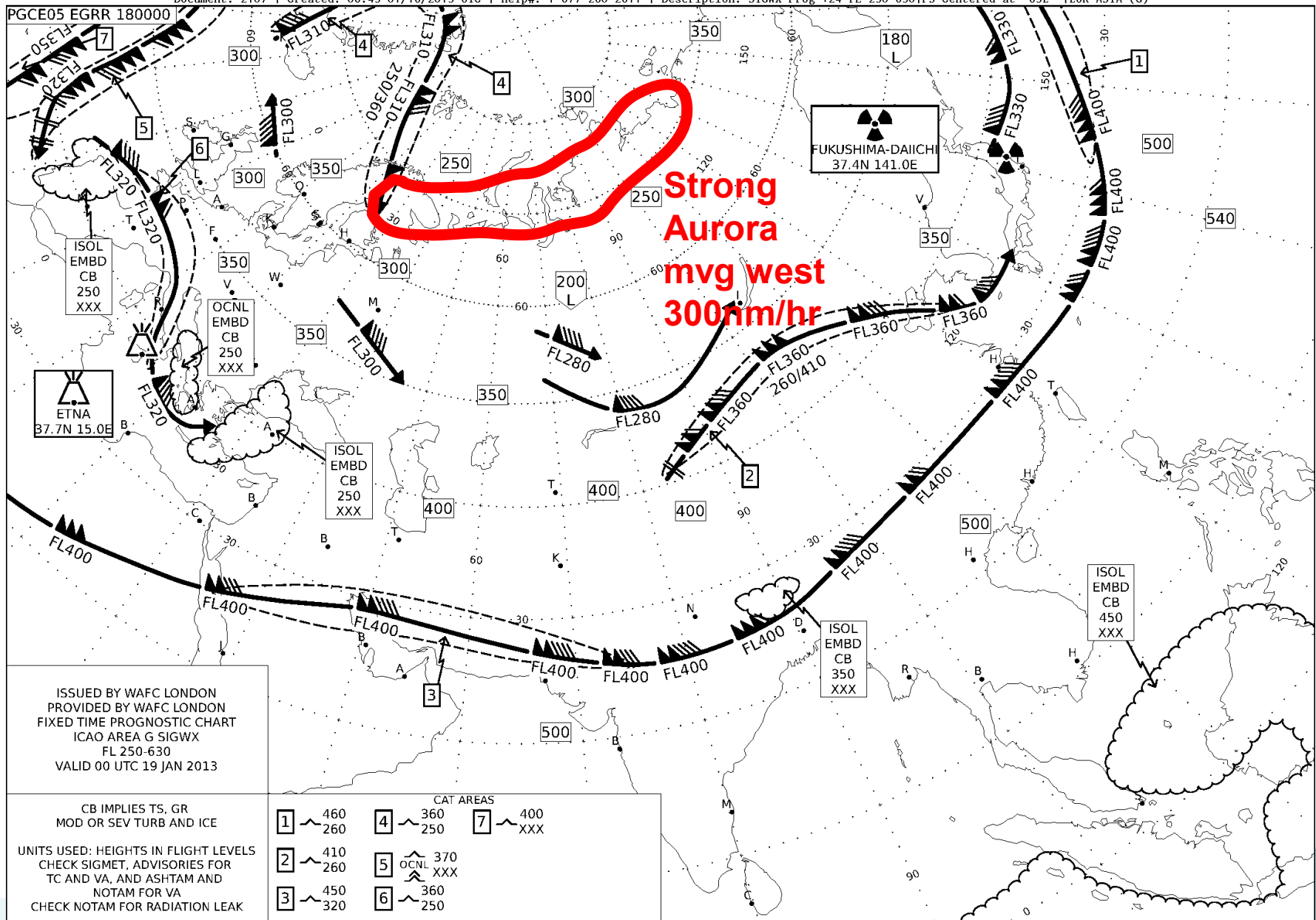
Weitere Informationen und Hintergründe zum Thema finden Sie auf der VC-Homepage unter Berufspolitik/Strahlenschutz.

Wir beobachten seit 6 Uhr heute morgen die Sonne ganz besonders genau und hoffen, Ihnen mit diesem Service behilflich zu sein.

Mit freundlichen Grüßen
Ihre AG Strahlenschutz

> e-mail alerts based on SWPC, Boulder, Co.

> maintained by VC Working Group Radiation Protection



Communication: proposal to add Aurora to SigWx Chart

ICAO/WMO standard Sigmets

> name

> validity

> meteorological phenomenon

> description of area affected
by name and/or coordinates

> brief outlook

SIGMETs:

EDUU RHEIN UIR

WS SIGMET 1 VALID 080850/081200
EDZF- EDUU RHEIN UIR SEV ICE OBS SW
OF LINE EDLV-EDQM AND NE OF LINE
ELLX- LOWS FL245/280 STNR NC=

severe
icing

EBBU BRUSSELS FIR

WS SIGMET 1 VALID 080640/081000
EBBR- EBBU BRUSSELS FIR SEV ICE OBS
N PART OF FIR FL250/260 FCST
FL150/250 MOV ESE NC=

severe
icing

EGTT LONDON UIR

WS SIGMET 02 VALID 080700/081100
EGRR- EGTT LONDON FIR SEV MTW FCST
NE OF LINE N5500 W00530 - N5220
W00530 - N5100 W00400 - N5300 E00315
FL050/180 STNR WKN=

mountain
wave

KZNY NEW YORK DOMESTIC LOWER

WS SIGMET LIMA 2 VALID 081955/082355
KKCI- NEW YORK
OCEANIC FIR MIAMI OCEANIC FIR SAN
JUAN OCEANIC FIR FRQ TS OBS AT 1955Z
WI N2600 W06615 - N2445 W06200 -
N2115 W06415 - N1615 W06400 - N1715
W06800 - N2200 W06800 - N2600
W06615. TOP FL500. STNR. INTSF=

thunder-
storms



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+++++ AIRPORT +++++  
1V230/10 VALID: 1004142230 - 1004152236  
GPS RAIM UNAVAILABLE FOR APPROACH AND DEPARTURE PROCEDURES  
04142230 TIL 04142240  
04152226 TIL 04152236
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Navigation: Aviation - standard GPS-RAIM u/s notam



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What do pilots need ?

- * accurate and reliable space weather and cosmic radiation forecasting
- * forecasts, measurements and warnings in standardized form, for the whole flight
- * continuous measurements of Space Weather, so warnings can be given with high priority when threshold levels of radiation, communication and navigation disturbance are exceeded.
- * distribution of forecasts , measurements and warnings analogous to the present ICAO / WMO weather and sigmet system.
- * Space Weather training for pilots, dispatchers and air traffic controllers

The road ahead is long - but the direction is clear.



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Thank you for your attention !

Cpt. Klaus Sievers
European Cockpit Association

3/2013

