



Space Weather - An Airline Perspective -

2017 Space Weather Workshop

Broomfield, CO

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Delta Air Lines, Inc.

NOAA's solar activity categories:

1. Radio Blackouts (R) Storm
2. Solar Radiation (S) Storm
3. Geomagnetic (G) Storm

Aviation Impacts:

- Radio Communications
- Health Affects



Summary: Solar Events & Actions

Solar Storms

Type of Storm		Sun → Earth	Duration	Affects		
<i>Abbrv.</i>		<i>Travel Time</i>	<i>Average</i>	<i>Aviation</i>	<i>Earth</i>	<i>Time</i>
Radio Blackout	R Storm	8 minutes	A few Hours	HF Radio	Equator	Daylight
Solar Radiation	S Storm	Approx. < 1 hour	< 1 day	HF Radio & Health	Poles	Any
Geomagnetic	G Storm	Approx. 18-24hrs	1-2 days	HF Radio	Poles	Any

Flight Superintendent Actions

Type of Storm		Storm Scale				
<i>Abbrv.</i>		<i>1</i>	<i>2</i>	<i>3</i>	<i>4</i>	<i>5</i>
Radio Blackout	R Storm	None	None	Awareness – HF issues on sun lit side		
Solar Radiation	S Storm	None	Aware	Avoid 78N to the Pole		
Geomagnetic	G Storm	None	Aware	Avoid 82N to the Pole		

Space Weather

Delta Meteorology Products

- Activity & Forecast Summary
- Threat Plot (TP) Messages

Space Weather Activity & Forecast Summary

1. Go to the Delta Weather Web site home page.

2. Mouse-over Forecast Products

3. Click on "Space Weather"

The current "Space Weather Activity & Forecast" summary will display

The screenshot shows the Delta Weather website interface. At the top, the browser title is "Delta Weather - Microsoft Internet Explorer provided by Delta Air Lines/Delta Technology". The address bar shows the URL "http://dalweb.delta.com/occ/occ_common/weather/dlwx.html". The website header includes the Delta Weather logo, navigation links for "User Guide", "Printable Maps", and "Contact Us", and the "Current UTC Time: 1608Z". Below the header is a menu with categories: Domestic, Canada/Alaska, Atlantic, Europe, Pacific, Latin America, Africa, Middle East, Forecast Products, and Tools. The "Forecast Products" menu is open, showing options: 5 Day Forecast, Deicing/IROP, Space Weather (highlighted with a red arrow), Tropical/IROP, and Volcano. The main content area features a "Maps" sidebar on the left with various map types like Convective Outlook, Critical Thickness, Freezing Level, etc. The central map is titled "Loop Image BaseRef/1605Z" and shows a weather map of North America with a color-coded scale at the bottom ranging from 0 to 65. The map includes labels for various airports and regions. At the bottom of the map, there are region codes (CONUS, NW, NC, NE, SW, SC, SE) and a "TP Text" button. The footer of the browser shows the URL "http://ftpweb.delta.com/weather/SPACEWX.pdf" and the text "Local intranet".

Activity & Forecast Summary

Summary Produced 2 X's EVERY Day

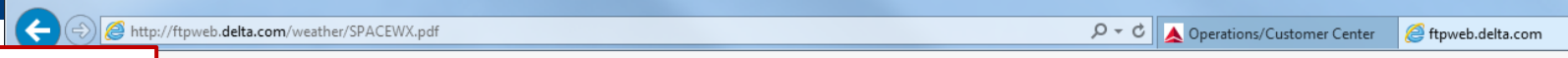
Browser: <http://ftpweb.delta.com/weather/SPACEWX.pdf>

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Delta Meteorology Space Weather Activity and Forecast							
Issue Time:	1100Z	Monday, April 24, 2017					
Next Update:	0100Z	Tuesday, April 25, 2017				*Valid Times See Below	
Fcstr:	LATTERY						
Previous 24 hour Activity							
From:		1100Z	4/23/2017	to		1100Z 4/24/2017	
	Event 1		Event 2 (if needed)		Event 3 (if needed)		
	Scale	Valid Time	Scale	Valid Time	Scale	Valid Time	
Geomagnetic Storms:	G1	23/1759Z	NONE		NONE		
Solar Radiation Storms:	NONE		NONE		NONE		
Radio Blackouts:	NONE		NONE		NONE		
Current Activity							
	Scale	Valid Time					
Geomagnetic Storms:	NONE		See latest TPs issued for:			G3, G4, G5	
Solar Radiation Storms:	NONE					S3, S4, S5	
Radio Blackouts:	NONE						
24 hour Forecast Activity							
				Valid thru:	0900Z	4/25/2017	
	Scale	Forecast Description:					
Geomagnetic Storms:	G1	Space weather for the next 24 hours is predicted to be minor. Geomagnetic storms reaching the G1 level are expected.					
Solar Radiation Storms:	NONE						
Radio Blackouts:	NONE						
LEGEND (for reference only)							

- Always Includes a Detailed Legend

Delta Threat Plot (TP) Procedures & Storm Scales



TP Issued ONLY When Needed

G or S Storm Scale of 3 or higher - required - Delta TP Alert

R Storm Scale of 3 or higher - Optional - Delta TP Advisory

LEGEND (for reference only)		
Avoid Polar Routes N of 82N (over ABERI, DEVID, RAMEL) ** S3, S4 or S5 Avoid All Polar Routes		Fly Polar Routes
Storm Scale	IP	Geomagnetic Storm Effects
G1	No TP Issued	Communications: No Effect Satellite Navigation: No Effect
G2	No TP Issued	Communications: Possible HF radio fade Satellite Navigation: No Effect
G3	Alert Issued (Required)	Communications: Possible intermittent HF radio outages Satellite Navigation: Possible intermittent satellite navigation problems
G4		Communications: Possible sporadic HF radio outages Satellite Navigation: Possible satellite navigation degraded for hours
G5		Communications: Possible HF radio outages for 1-2 days Satellite Navigation: Possible satellite navigation degraded for days
Storm Scale	TP	Solar Radiation Storm Effects
S1	No TP Issued	Communications: Possible minor effects on HF Radio Satellite Navigation: No Effect Biological: No Effect
S2	No TP Issued	Communications: Possible small effects on HF Radio Satellite Navigation: Possible navigation at polar cap affected Biological: Possible elevated radiation risk
S3**	Alert Issued (Required)	Communications: Possible HF radio degradation Satellite Navigation: Possible satellite navigation errors Biological: Possible elevated radiation risk
S4**		Communications: Possible blackout of HF radio for several days Satellite Navigation: Possible satellite navigation errors for several days Biological: Possible elevated radiation risk
S5**		Communications: Possible complete blackout of HF radio for several days Satellite Navigation: Possible satellite navigation errors for several days Biological: Possible elevated radiation risk
Storm Scale	TP	Solar Flare - Radio Blackout Effects
R1	No TP Issued	Communications: Possible minor degradation to HF radio on sunlit side of Earth Satellite Navigation: No Effect
R2	No TP Issued	Communications: Possible blackouts to HF radio for tens of minutes on sunlit side of Earth Satellite Navigation: No Effect
R3	Advisory Issued (if needed)	Communications: Possible blackouts to HF radio for an hour on sunlit side of Earth Satellite Navigation: No Effect
R4		Communications: Possible blackouts to HF radio for 1-2 hours on sunlit side of Earth Navigation: Possible minor disruptions to satellite navigation on sunlit side of Earth
R5		Communications: Possible complete blackout to HF radio for several hours on sunlit side of Earth Satellite Navigation: Possible satellite navigation errors for several hours on sunlit side of Earth

*** Radio Blackouts impact the entire sunlit side of the earth. They also serve as a warning for potential Geomagnetic storms or Solar Radiation storms (1/2hr-1 day from Sun to Earth). ***

Space Weather Info

Delta TP Product Examples

To Support Pre-flight Planning & En Route Decision Making:

Meteorology will issue TP Messages for R3 or greater as “Advisory”

S & G scale 3 or greater are “Alerts” (action may be needed)

TP AO26 241604Z

1.AO

2.* **ADVISORY** *

HAZ:SPACE WX

SOURCE:OBSERVED

CATEGORY:R3

LAT/LON:90.0N100.0W

RADIUS:480NM

TIME:POSN AT 24/1600Z

ALTS:FL300-500

INFO:SOLAR FLARE WITH

NO IMPACT TO

POLAR RTES KNOWN OR

FCST AT THIS TIME.

3.VALID 241604/241804Z

4.CANCEL NONE

TP AO30 241608Z

1.AO

2.* **ALERT** *

HAZ:SPACE WX

SOURCE:FORECAST

CATEGORY:S3

LAT/LON:90.0N100.0W

RADIUS:780NM

TIME:POSN AT 24/1600Z

ALTS:FL300-500

INFO:RCMND AVOIDING

ALL POLAR RTES.

3.VALID 241800/250400Z

4.CANCEL NONE

TP AO31 241609Z

1.AO

2.* **ALERT** *

HAZ:SPACE WX

SOURCE:FORECAST

CATEGORY:G3

LAT/LON:90.0N100.0W

RADIUS:480NM

TIME:POSN AT 24/1600Z

ALTS:FL300-500

INFO:RCMND AVOIDING

POLAR RTES N OF 82N.

3.VALID 241800/250400Z

4.CANCEL NONE

Types and Hazard Intensity

TP Message Products

- Forecast Activity
Used for Preflt Planning
- Current Activity
Used En Route

Outlook/Summary Products

Compliments TP Products
Used by Dispatcher as initial info

AVOID

Sev Icing
Volcanic Ash
Strong Mtn Wave
> Moderate Turbc

ALERT

Moderate Icing
Moderate Turbulence
Moderate Mtn Wave, Tstrms, Ozone
Space Weather (S & G level 3 or >)

ADVISORY

Frontal Shear
Light-Moderate Turbulence
Space Weather (R level 3 or greater)



Delta Avoidance HF Comms & Health Related

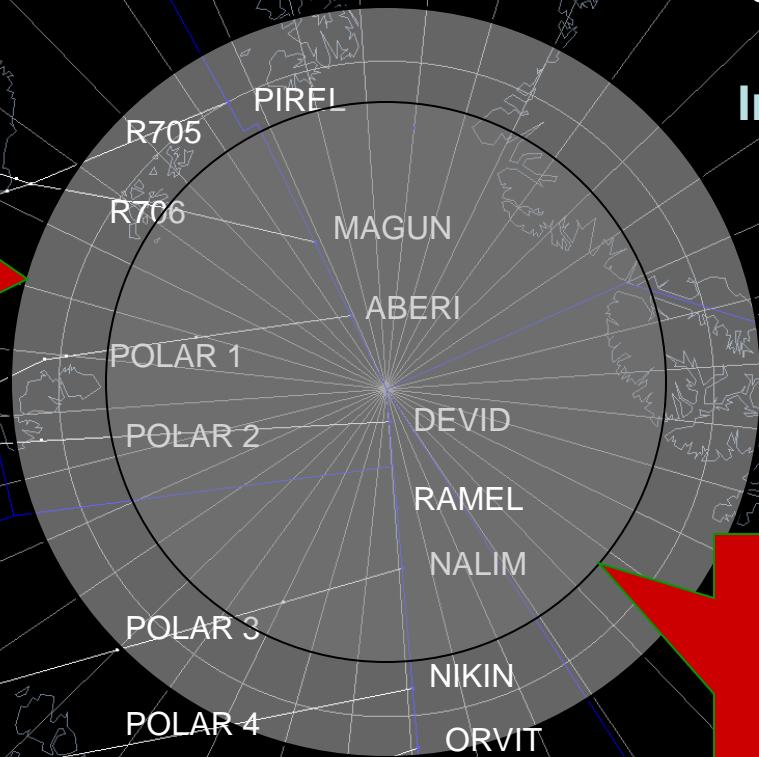
Each flt must maintain constant communication with ATC & with the company.

Delta's Primary Comms Method: ACARS using VHF or SATCOM

Delta's Secondary Comm Method: Voice Communications using HF Radio or SATCOM

Health

No Ops on all Polar Routes During Strong Solar Radiation (S) Storms Due psbl Health affect



Communications

Inmarsat SATCOM is not available North of 82N. ~~ACARS~~ or ~~Voice~~ SATCOM

VHF ACARS is not available in the Polar Region.

Voice HF Radio only option

No Ops North of 82N During Strong (G) Geomagnetic Storms Due psbl loss HF



Dispatch Procedures Summary

Dispatcher ACTIONS:

- The ***Space Weather Activity & Forecast*** product is referenced daily by dispatch.
 - Also consulted for aircraft operating in theaters other than the Polar Theater that are not equipped with SATCOM & rely on HF radio for communications
- ***TP Messages*** are only issued when significant Space Weather affects Delta flts.
 - If a Space Weather TP indicates geomagnetic or solar radiation storms of level 3 or higher, Polar routes will be avoided (G Storm: 82N or above & R Storm: 78N or above).
- ***All Polar Operations*** regardless of Space Weather Threats:
 - Due to extreme cold temperatures North of 78 degrees, Delta samples the fuel density at departing stations (MSP/DTW/ATL) to derive actual fuel freeze limits.
 - Adjustment is made to fly an Off-Optimum (time/cost) Route if fuel freeze threat exists.

Crew Members' OPTION:

- A crew member on a Reserve Flight Schedule can opt out of flying on a city pair that may use Polar Routes if they are pregnant.

Delta Air Lines

Conclusions

Delta' Ops Concerns:

- HF Radio Communication disruption is a concern
- Improved Space Wx Fcsting needed for both safety & efficiency

Space Wx Info Needs

- As simplified as psbl for Aviation Ops Decisions
- Support “H” (Health) Scale. Implement after details addressed.

Performance Values for Space Weather Forecasting

- There has been a lot of work on Performance Values
- Delta's Requests:
 - Clear labeling that Perf Values are a goal not a mandate
 - Re-routes remain responsibility of Operator, not ANSP
 - Forecasting efforts should not over reach capabilities
 - An inaccurate 30hr forecast is a disservice



Questions