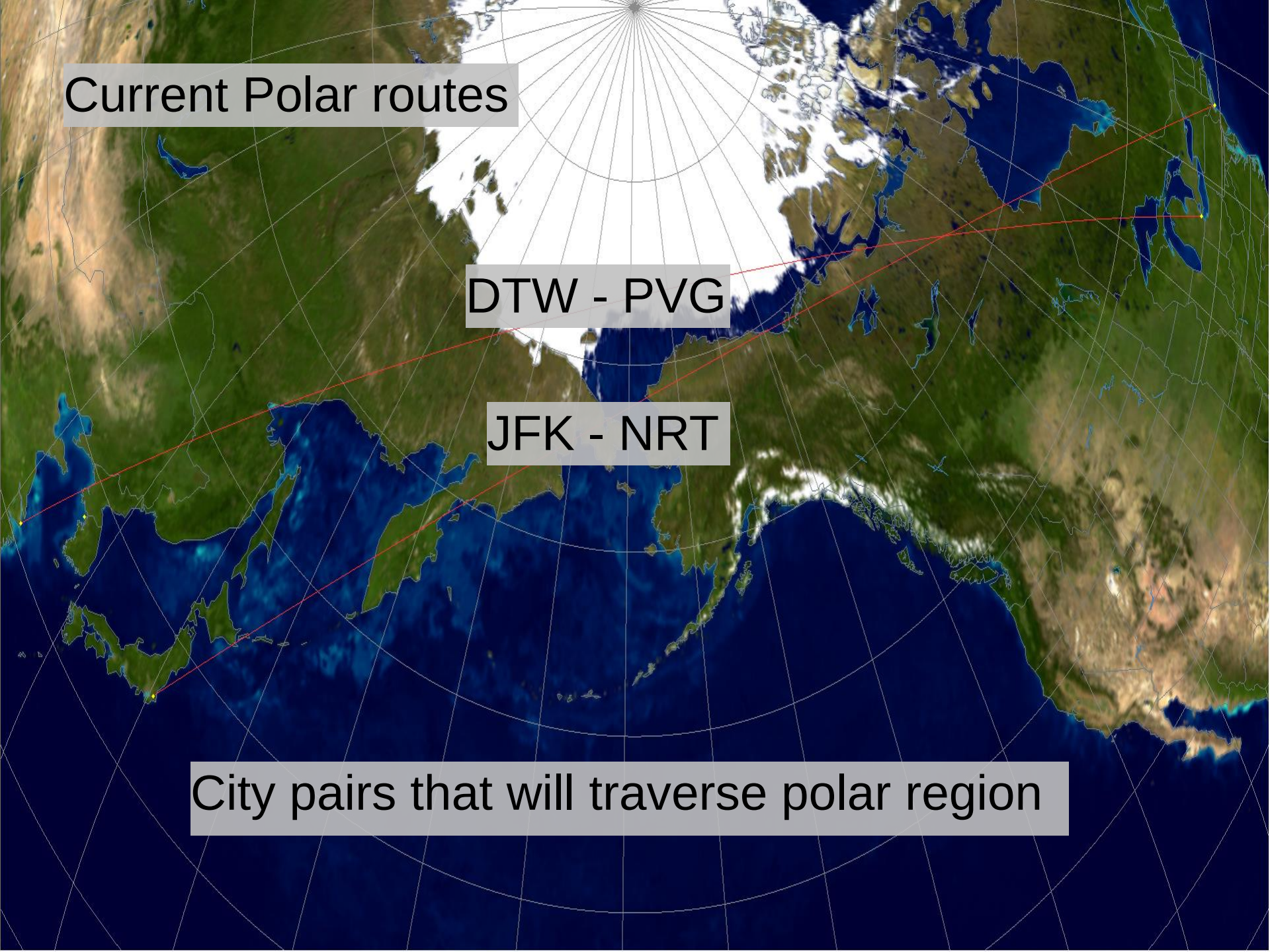
Space Weather and Delta's Polar Routes

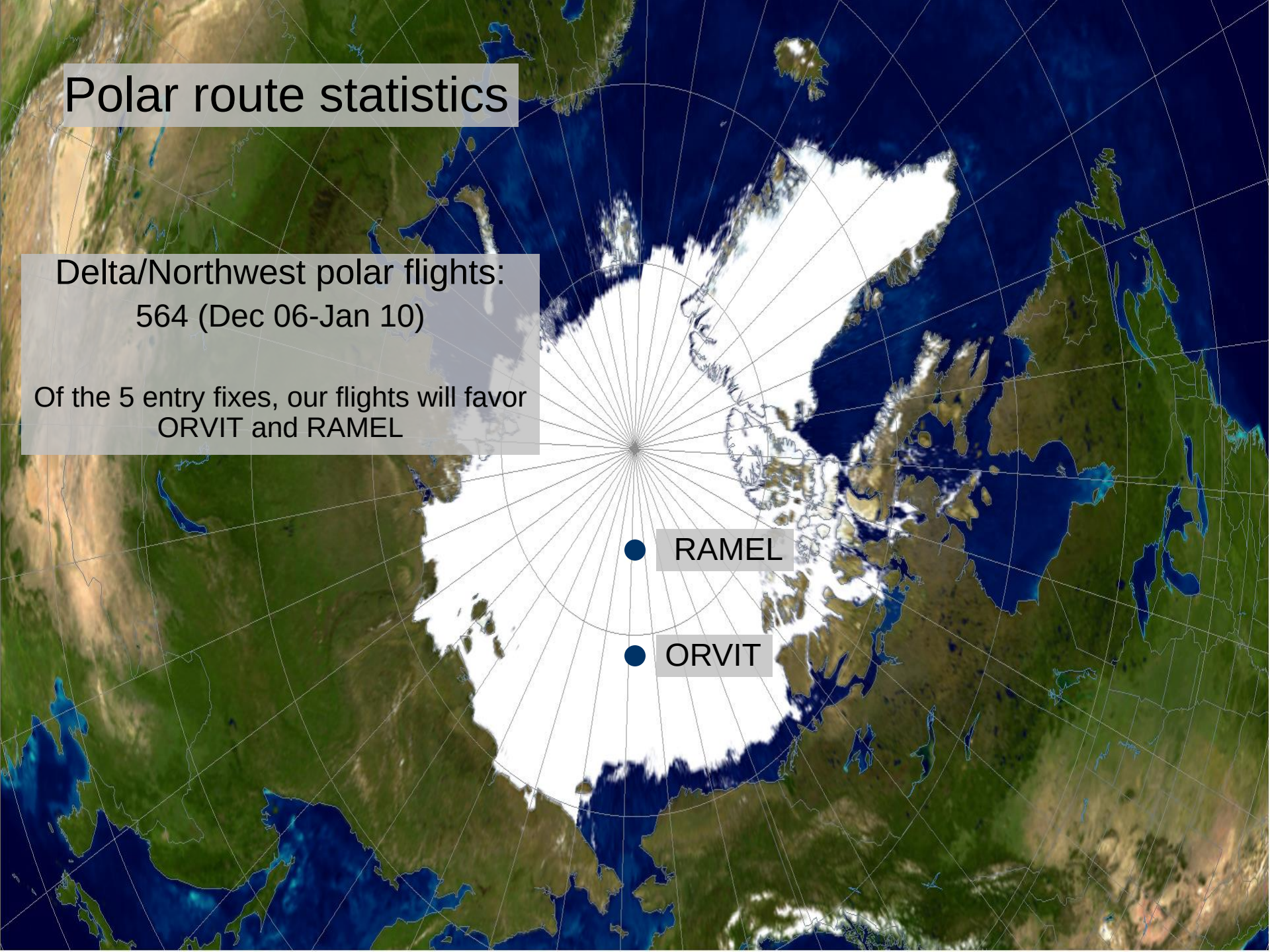
Polar Routes and Fixes

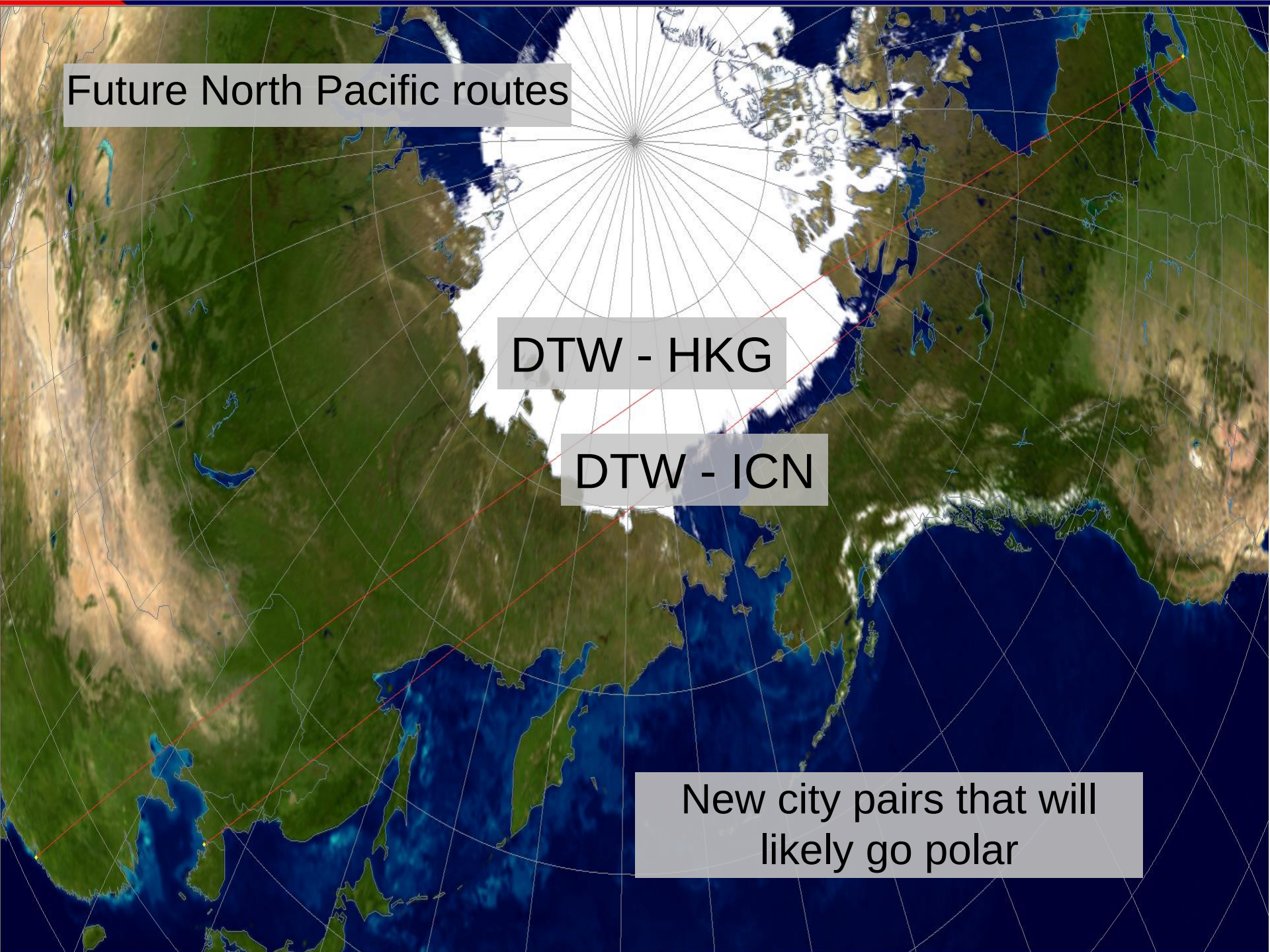

Current Polar routes
DTW - PVG
JFK - NRT
City pairs that will traverse polar region

Polar route statistics

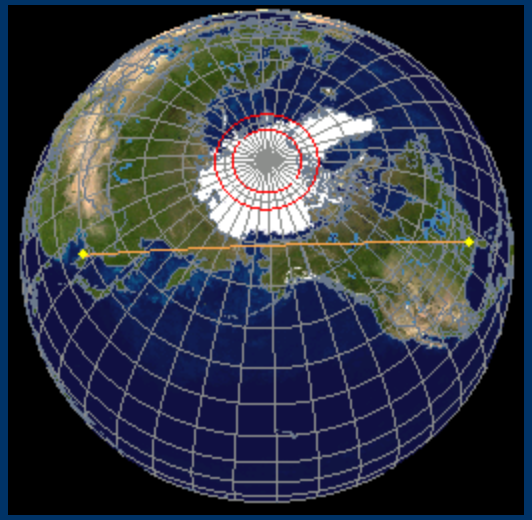
Delta/Northwest polar flights:
564 (Dec 06-Jan 10)

Of the 5 entry fixes, our flights will favor ORVIT and RAMEL




Future North Pacific routes
DTW - HKG
DTW - ICN
New city pairs that will likely go polar

Requirements for Operating in the Polar Area:



- Authorization for operating in areas of magnetic unreliability
- Procedure for fuel freeze
- Effective communication for all portions of the flight route
- The following MELS (Minimum Equipment List):
    - Fuel quantity/temperature indicating system
    - Auto-throttle System
    - Communications system
    - Medical Kit to include AED
    - Include MEL restrictions for 180-min operation
    - APU
- Training
    - QFE/QNH and meter/feet conversion
    - Fuel freeze
    - Area and route-specific weather patterns and aircraft system limitations
    - Special considerations into diversion airports
    - Cold weather anti-exposure suit (2 onboard)
- Suitable alternate airports

Delta Meteorology's Role in Space Weather Planning

- Authorization for operating in areas of magnetic unreliability
- **Procedure for fuel freeze**
- **Effective communication for all portion of the flight route**
- The following MELS:
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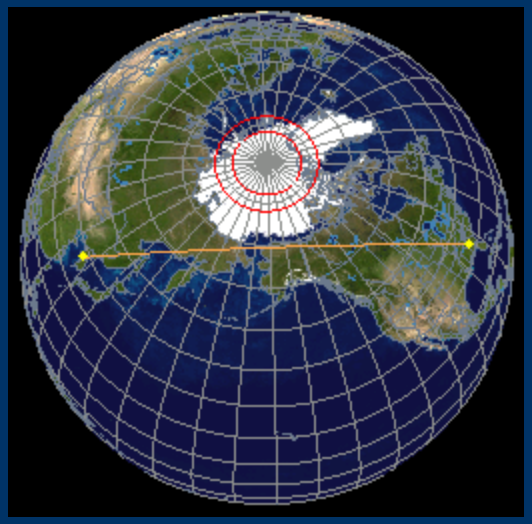
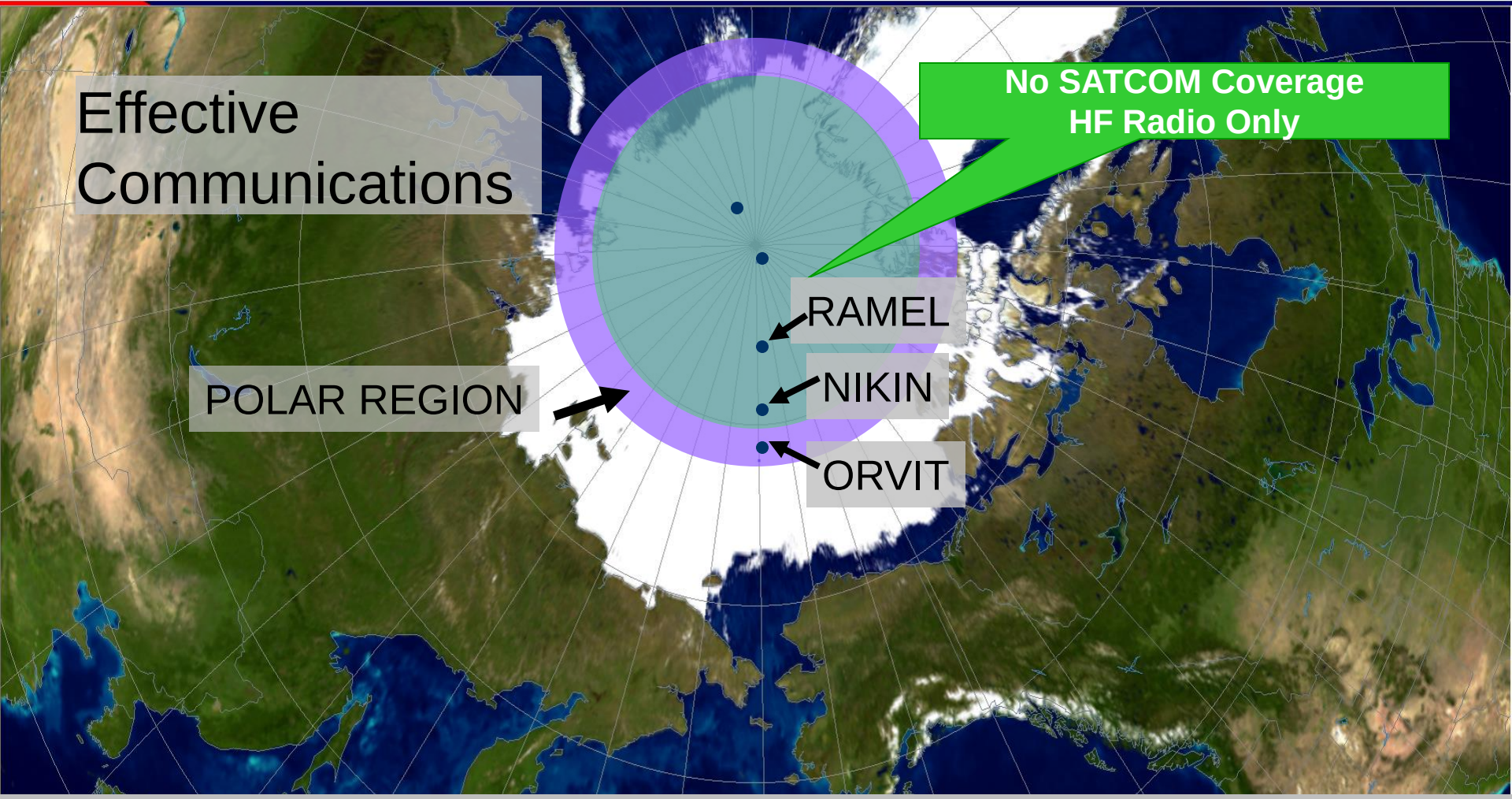
- **Suitable alternate airports**



Storm Scales

Storm	Scale	
Geomagnetic	G1, G2	FLY
	G3, G4, G5	NO FLY (ABERI, RAMEL, DEVID)
Solar Radiation	S1, S2	FLY
	S3, S4, S5	NO FLY
Radio Blackout	R1, R2	FLY
	R3, R4, R5	NO FLY

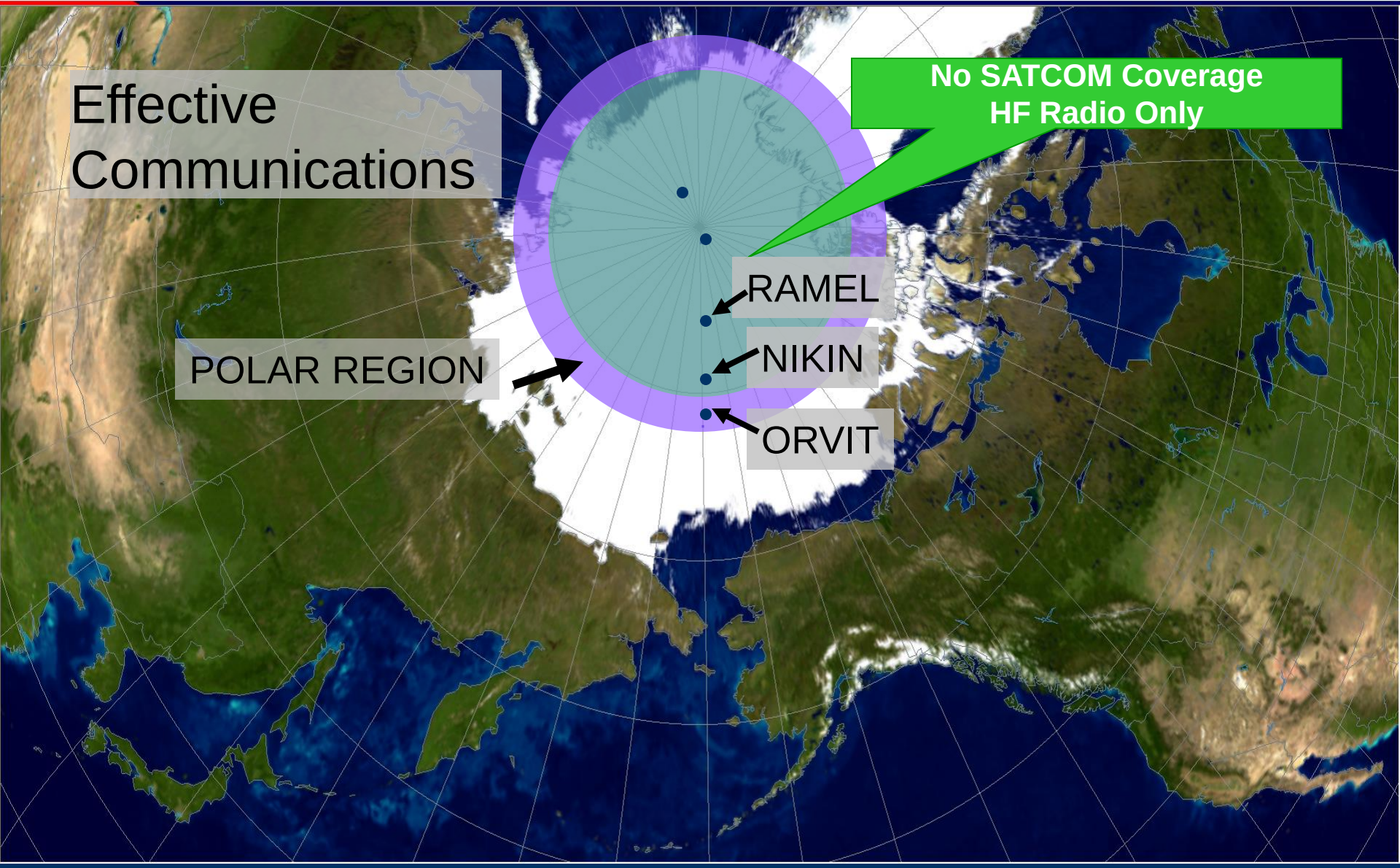
Space Weather Effects on SATCOM/HF Radio



Delta's Primary Communication Method: ACARS using VHF or SATCOM
Delta's Secondary Communication Method: Voice Communications using HF Radio or SATCOM

SATCOM is not available North of 82N. Any flights entering north of ORVIT must on rely HF Radio as a primary source to communicate with ATC and Delta.

But Solar Activity can interfere with HF Radio, which could mean no communication method is available.

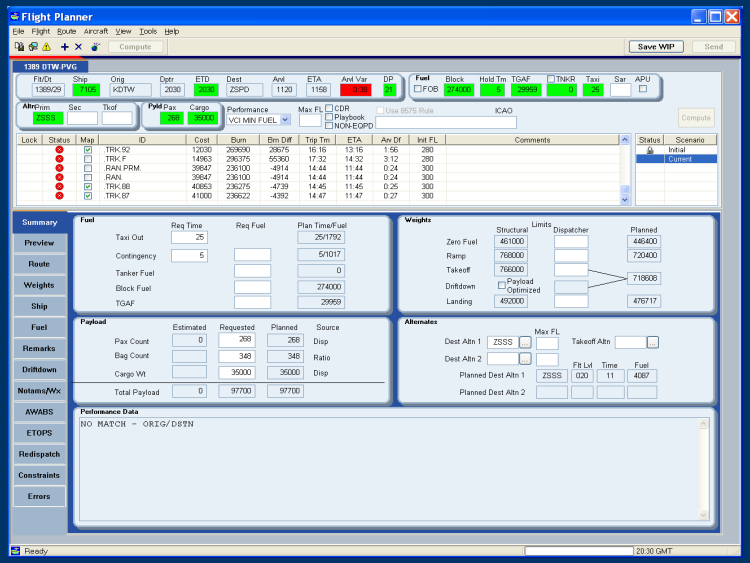


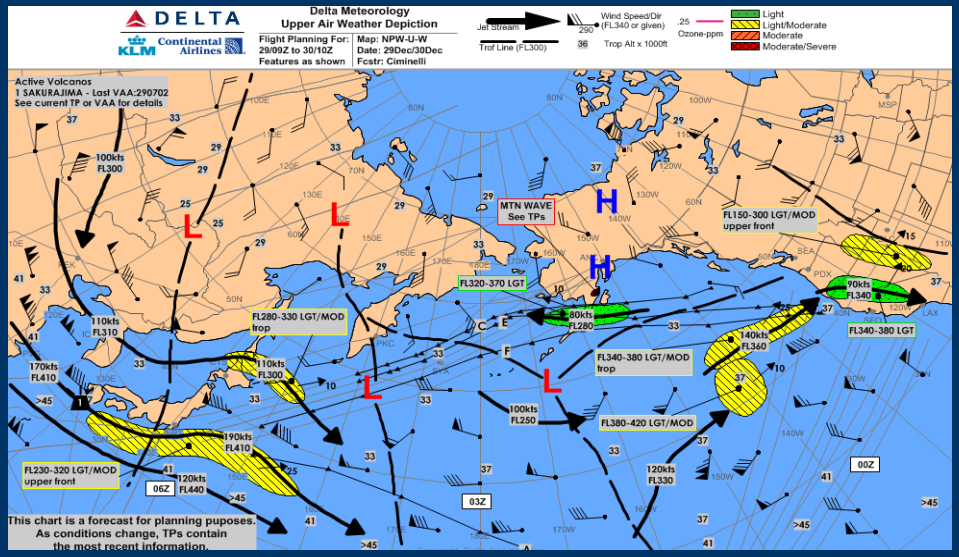
We can enter via ORVIT, during a small Geomagnetic Storm or Radio blackout because it is within SATCOM range. We will not fly any polar routes during a moderate or larger solar radiation storm due to effects on communications and possible radiation exposure.

Planning a Polar Flight

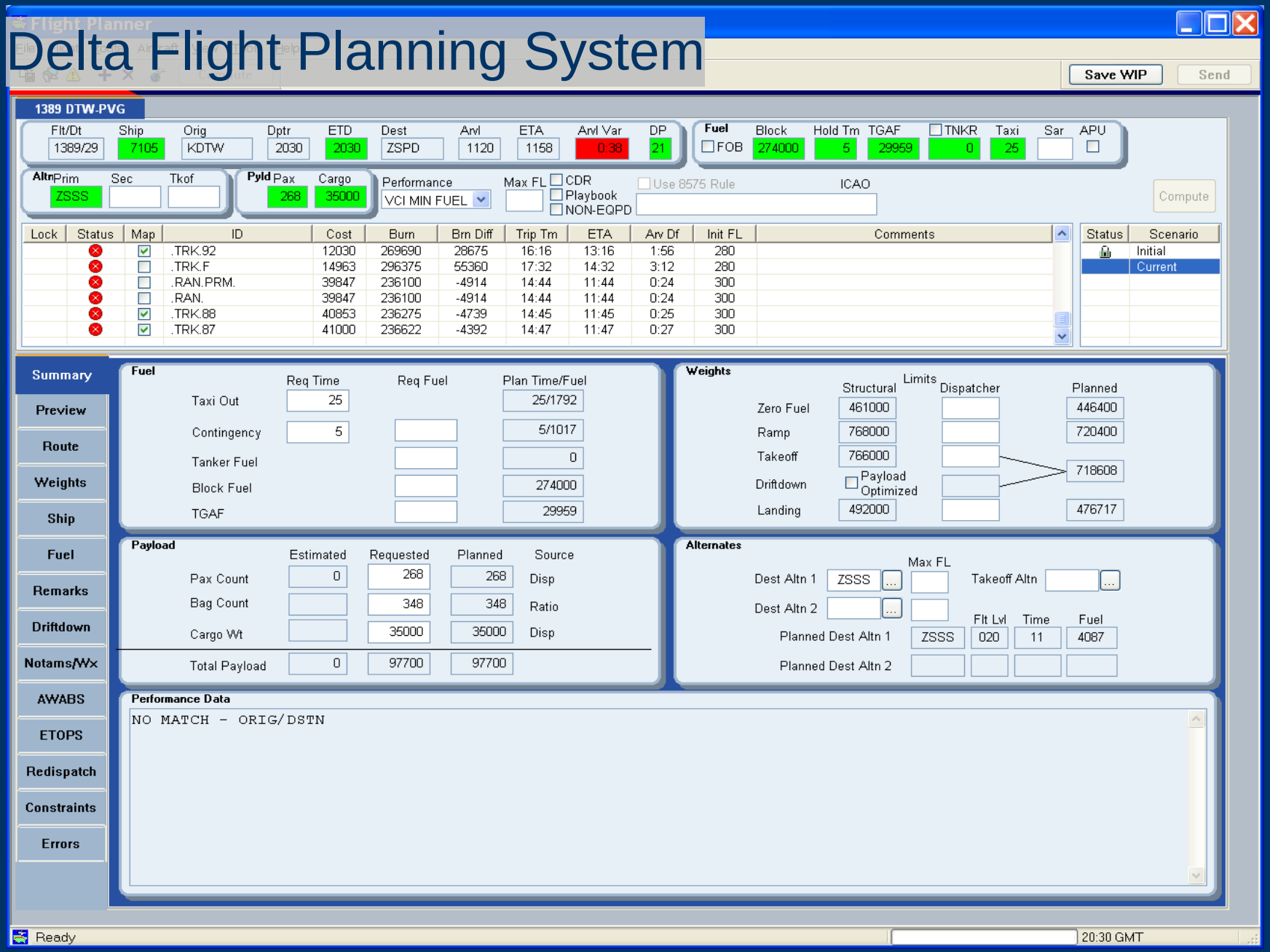
Planning phase of flight

- Run analysis through FPS for each flight to determine best routes and flight levels
- Polar routes will almost always be more economical
- Consider Meteorology department's random routes
- Determine safest route - forecast weather (turbulence, thunderstorms, space weatther activity, cold temps)
- Evaluate alternate airports

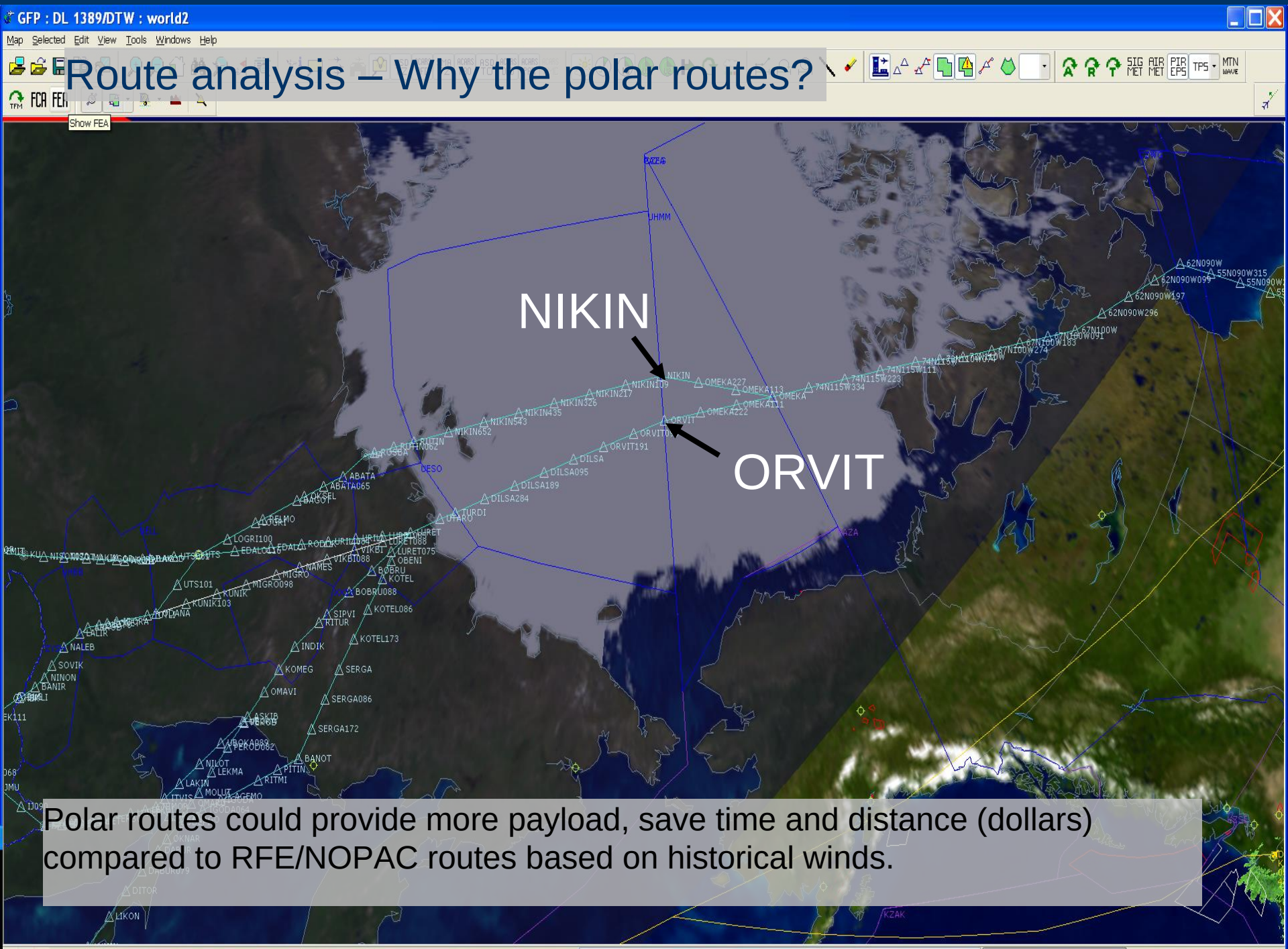




Delta Flight Planning System

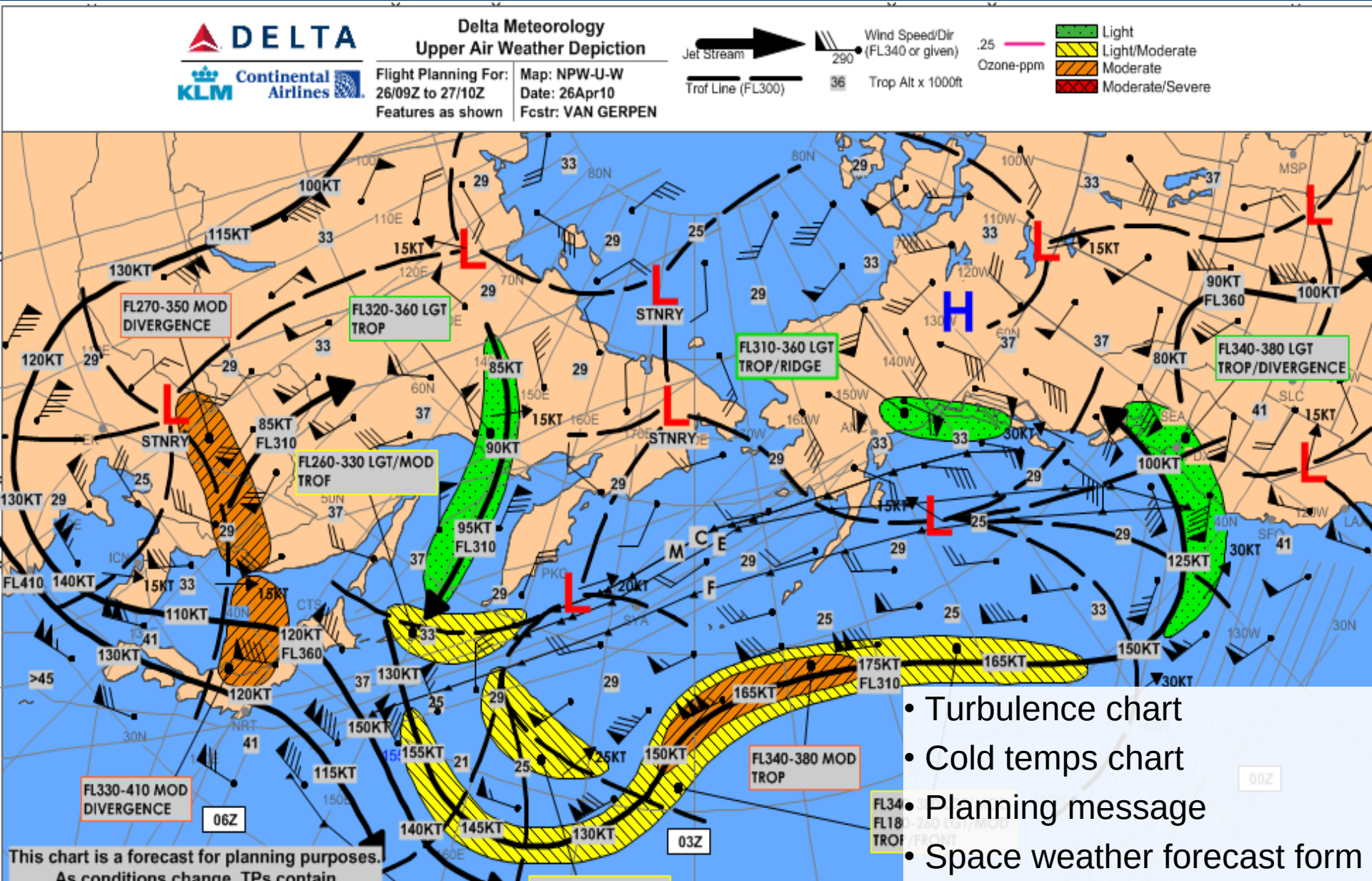


Route analysis – Why the polar routes?



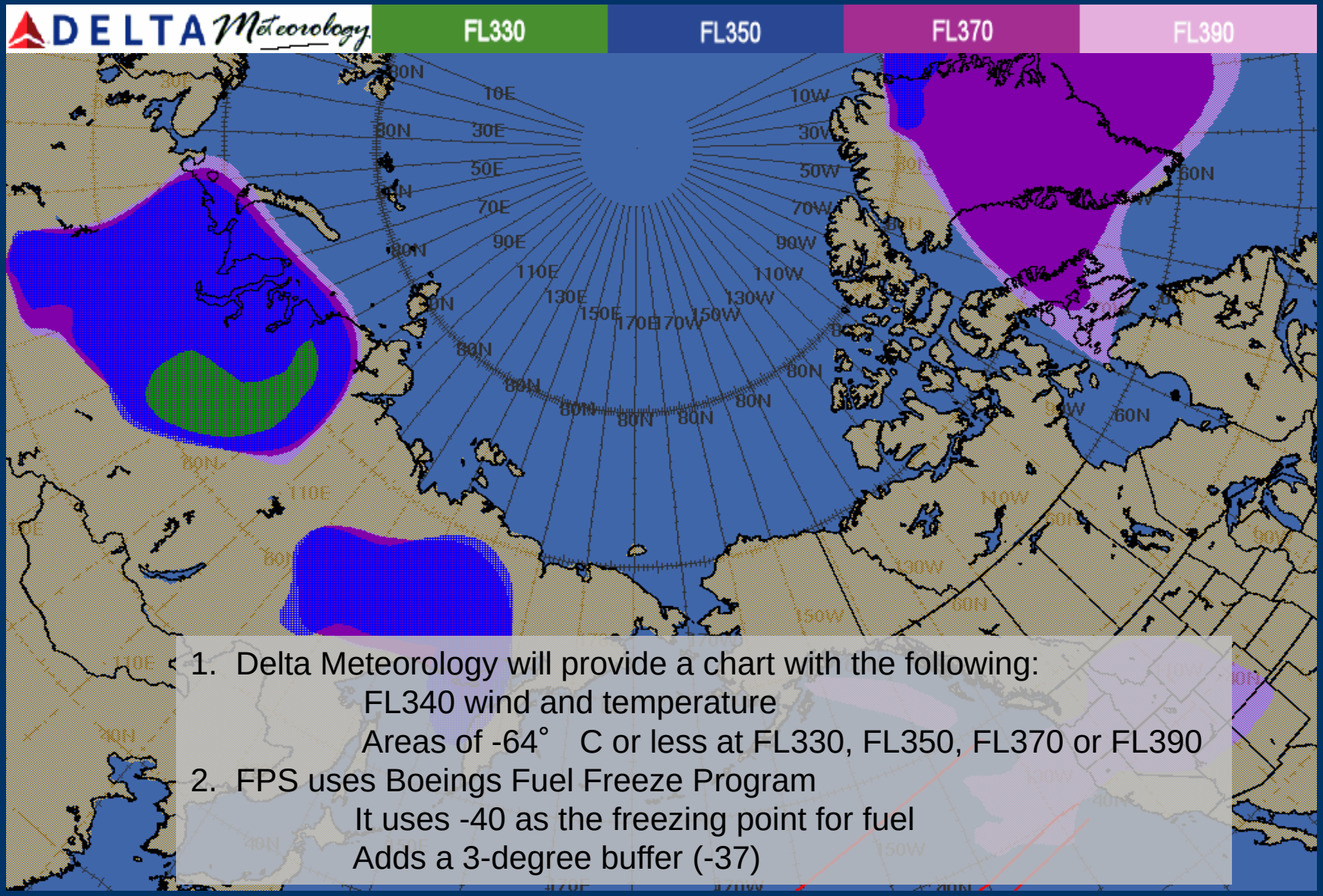
Polar routes could provide more payload, save time and distance (dollars) compared to RFE/NOPAC routes based on historical winds.

Create forecast packet



- Turbulence chart
- Cold temps chart
- Planning message
- Space weather forecast form

Cold temp chart (-64C)



1. Delta Meteorology will provide a chart with the following:
   - FL340 wind and temperature
   - Areas of -64˚ C or less at FL330, FL350, FL370 or FL390
2. FPS uses Boeings Fuel Freeze Program
   - It uses -40 as the freezing point for fuel
   - Adds a 3-degree buffer (-37)

Space Weather Forecast Form – part 1

Delta Meteorology Space Weather Activity and Forecast

Date: Monday, April 26, 2010
Valid: Monday, April 26, 2010 thru Tuesday, April 27, 2010
Fcstr: SEXTON

Current NOAA Scales Activity

Geomagnetic Storms:	NONE
Solar Radiation Storms:	NONE
Radio Blackouts:	NONE

Solar Activity Forecast

Solar activity is expected to remain very
low for the next 3 days (Apr 26-28).

Geomagnetic Field Activity Geophysical Activity Forecast: The geomagnetic field is

The geomagnetic field is expected to be mostly quiet on day one (26 April). Quiet to unsettled levels are expected on days 2 and 3 (27-28 April) with isolated
active periods possible on day 3 in response to the CME observed on
22 April.

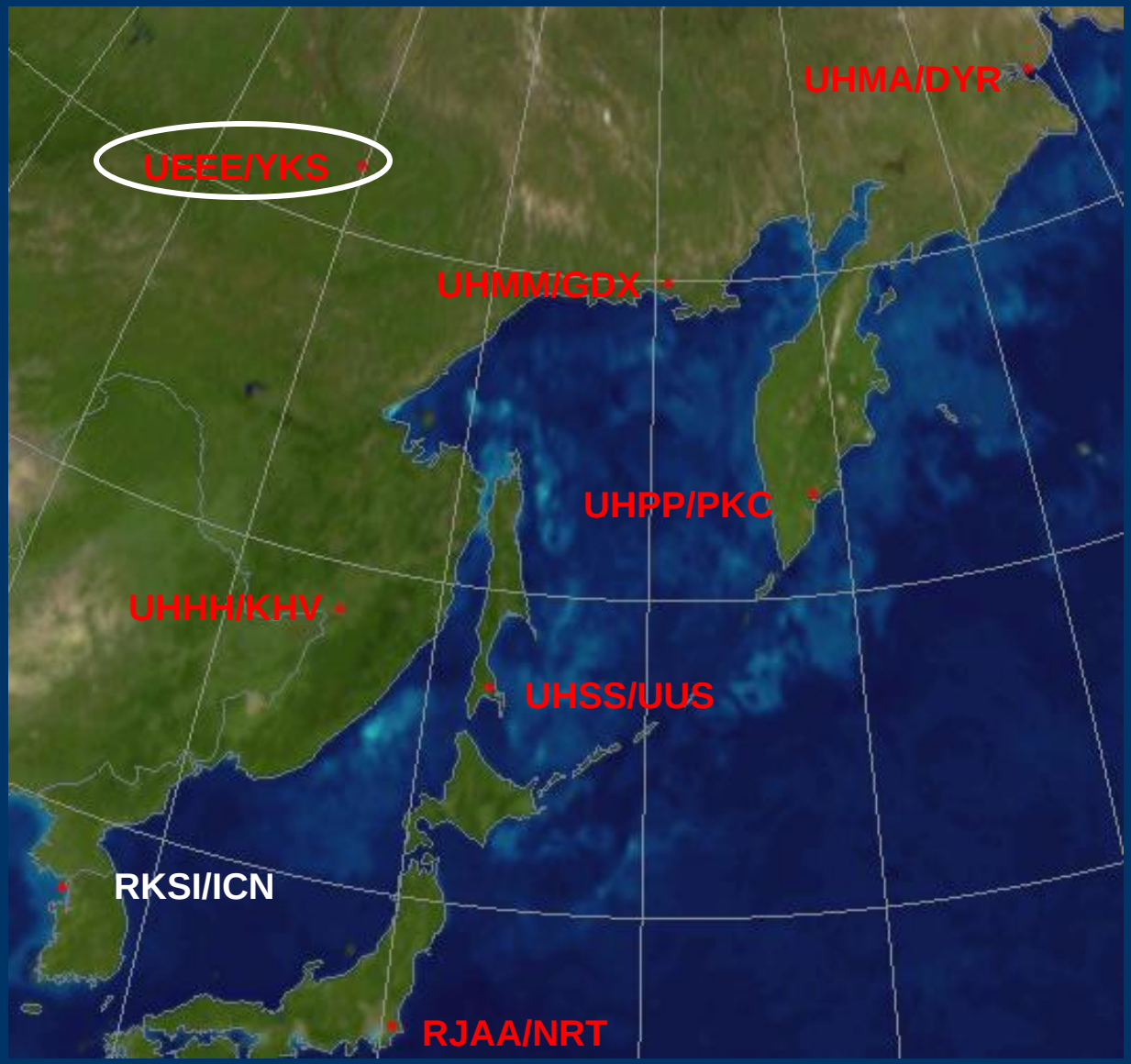
Space Weather Forecast Form – part 2

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

This section does not change. It is effects of each type of storm on HF Radio, Satellite Navigation and/or Biology

Suitable Airports in Russia

Russian ETP's



Yukutsk – UEEE/YKS

An ETP airport is considered unsuitable when the surface temperature is colder than -40F. The meteorologist will need to make a remark on the flight planning message if one of our ETP airports are this cold.

The greatest threat is YKS, where the average January high is -36F!

```
 SURFACE WEATHER«
YKS  060600 METAR 060600Z 00000MPS 0450 R23L/0550N FG BKN200«
   M39/M43 Q1054          NOSIG RMK QFE782 23450150«
YKS  060700 METAR 060700Z 00000MPS 0450 R23L/0600V0800U FG«
   BKN200 M38/M43 Q1054          NOSIG RMK QFE781 23450150«
YKS  060800 METAR 060800Z 00000MPS 0600 R23L/1400D FG BKN200«
   M39/M43 Q1054          NOSIG RMK QFE781 23450150«
YKS  060800 METAR 060830Z 00000MPS 0400 R23L/1100D FG BKN200«
   M39/M43 Q1054          NOSIG RMK QFE781 23450150«
                                                          «
```

Space Weather Activity Procedures

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22 April.

Enroute Notification

Meteorology department printer will immediately receive alerts/warnings from SWPC.

The meteorologist will

- Notify Flight Control of any activity that is occurring or forecast to occur
- Issue TP

Enroute Response

For Geomagnetic Storms or Radio blackouts:

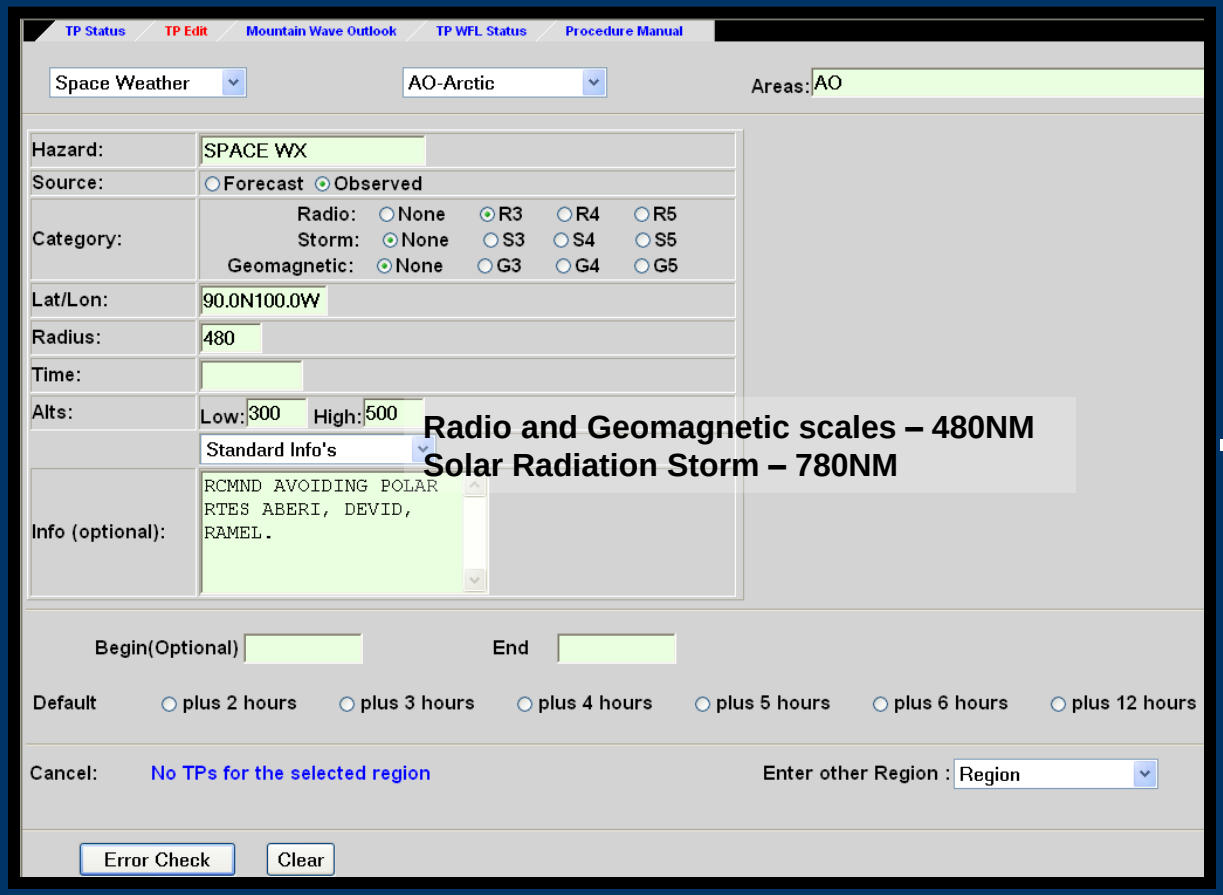
- Dispatcher and flight crew amend flight route if needed
- Relay TP information

For Solar Radiation Storms:

- Surface meteorologist will receive the Solar Radiation Alert
- Flight Control/Crew determine best altitude to minimize radiation dose for the remainder of the flight.
- Likely drop to lower flight level or change entire route.
- Relay TP information

Turbulence Plot (TP) System – Space Weather

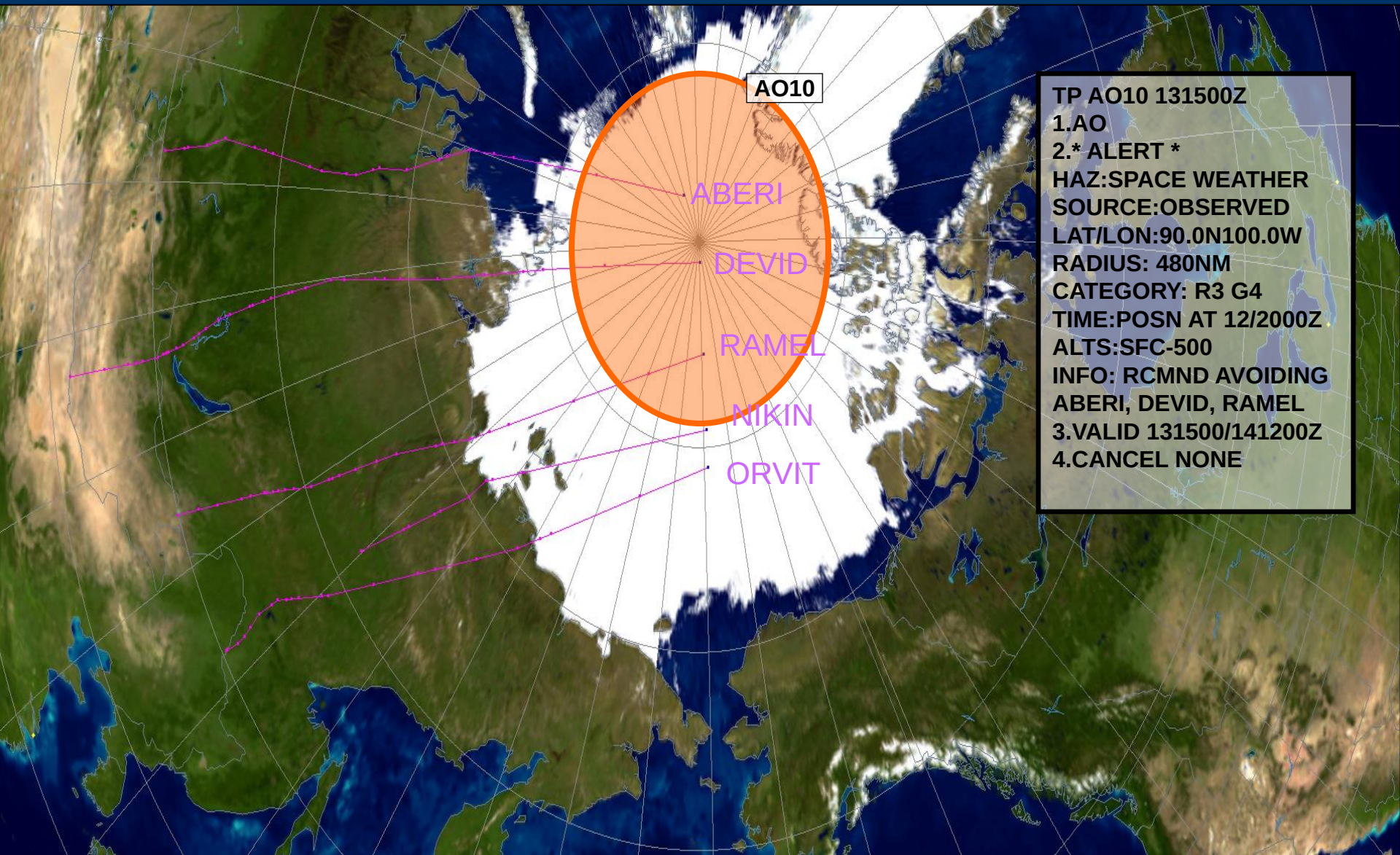
TP System: Delta Air Lines' primary method for weather hazard avoidance



TP AO10 131500Z
1.AO
2.* ALERT *
HAZ:SPACE WEATHER
SOURCE:OBSERVED
LAT/LON:90.0N100.0W
RADIUS: 780NM
CATEGORY: S3 R3 G3
TIME:POSN AT 12/2000Z
ALTS:FL300-500
INFO: RCMND AVOIDING ALL POLAR ROUTES
3.VALID 131500/141200Z
4.CANCEL NONE

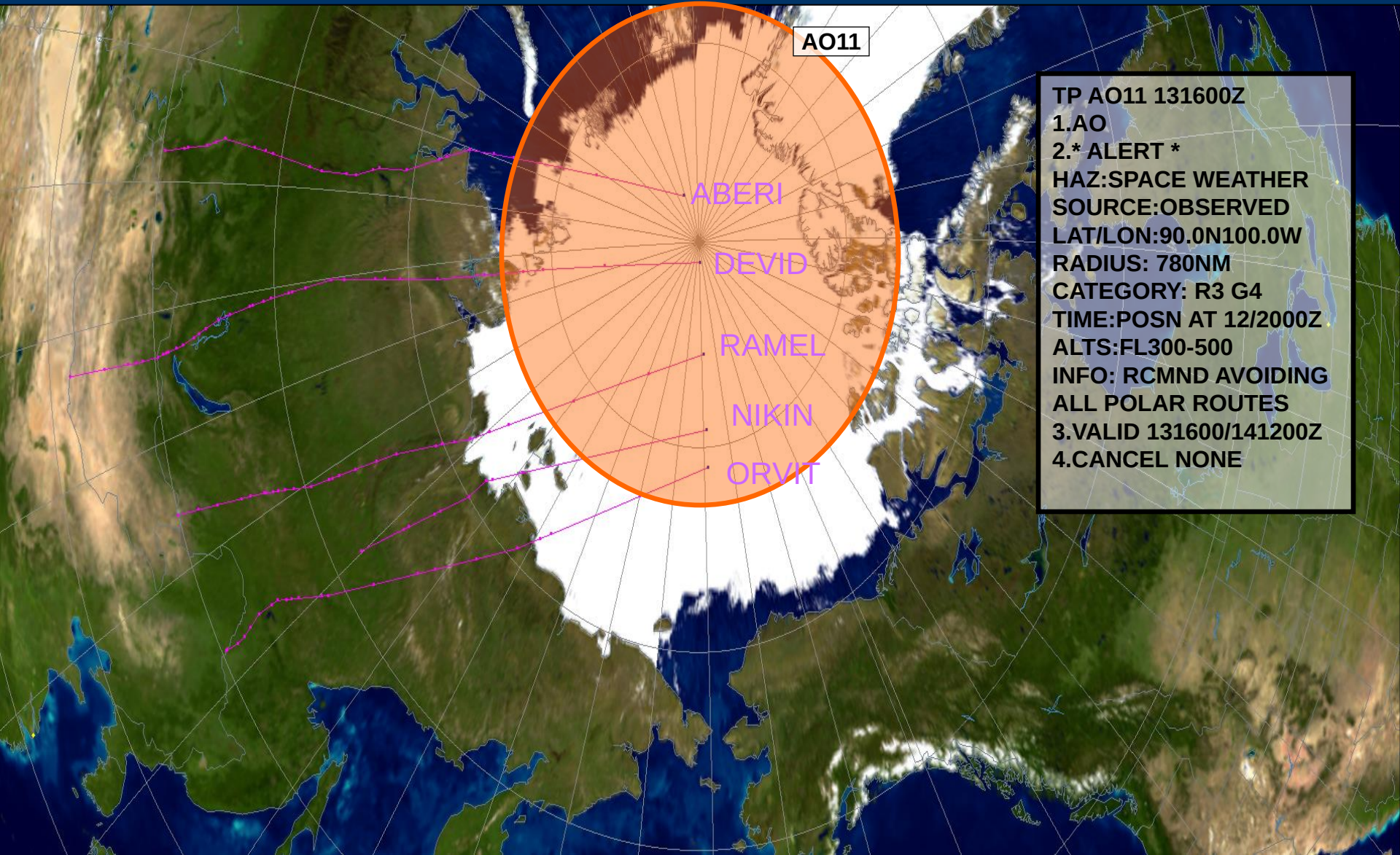
Space Weather TP Messages

G and R Scale Storms – 480NM Radius

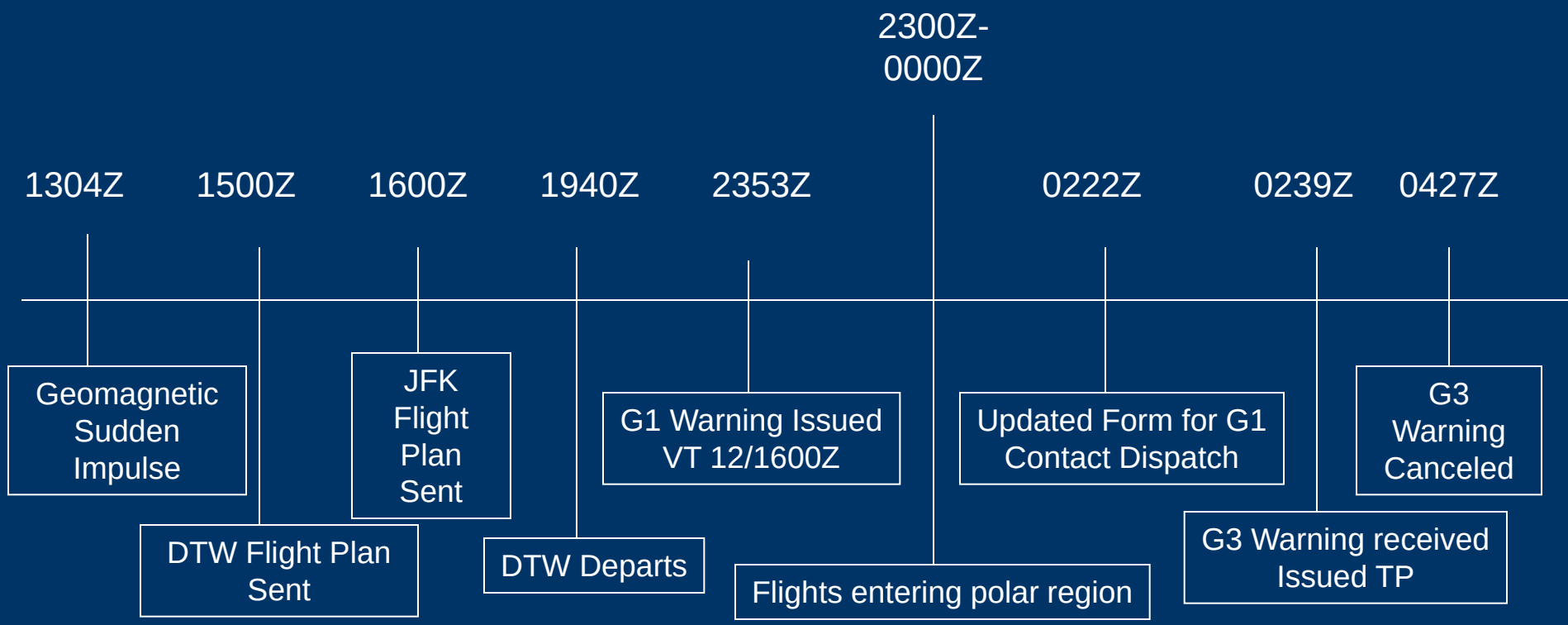


Space Weather TP Messages

S Scale Storms – 780NM Radius



April 11th-12th 2010 Event



What do we need from SWPC?

- Continued communication/education between our groups
- Timely communication of space weather events
- Warnings to include affected geographical areas/flight levels/latitude restrictions
- Duration of conditions