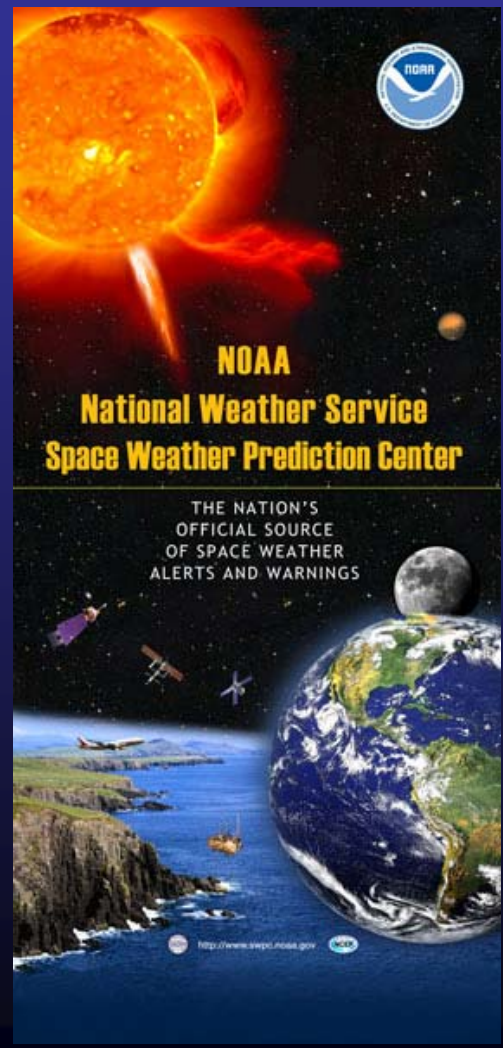
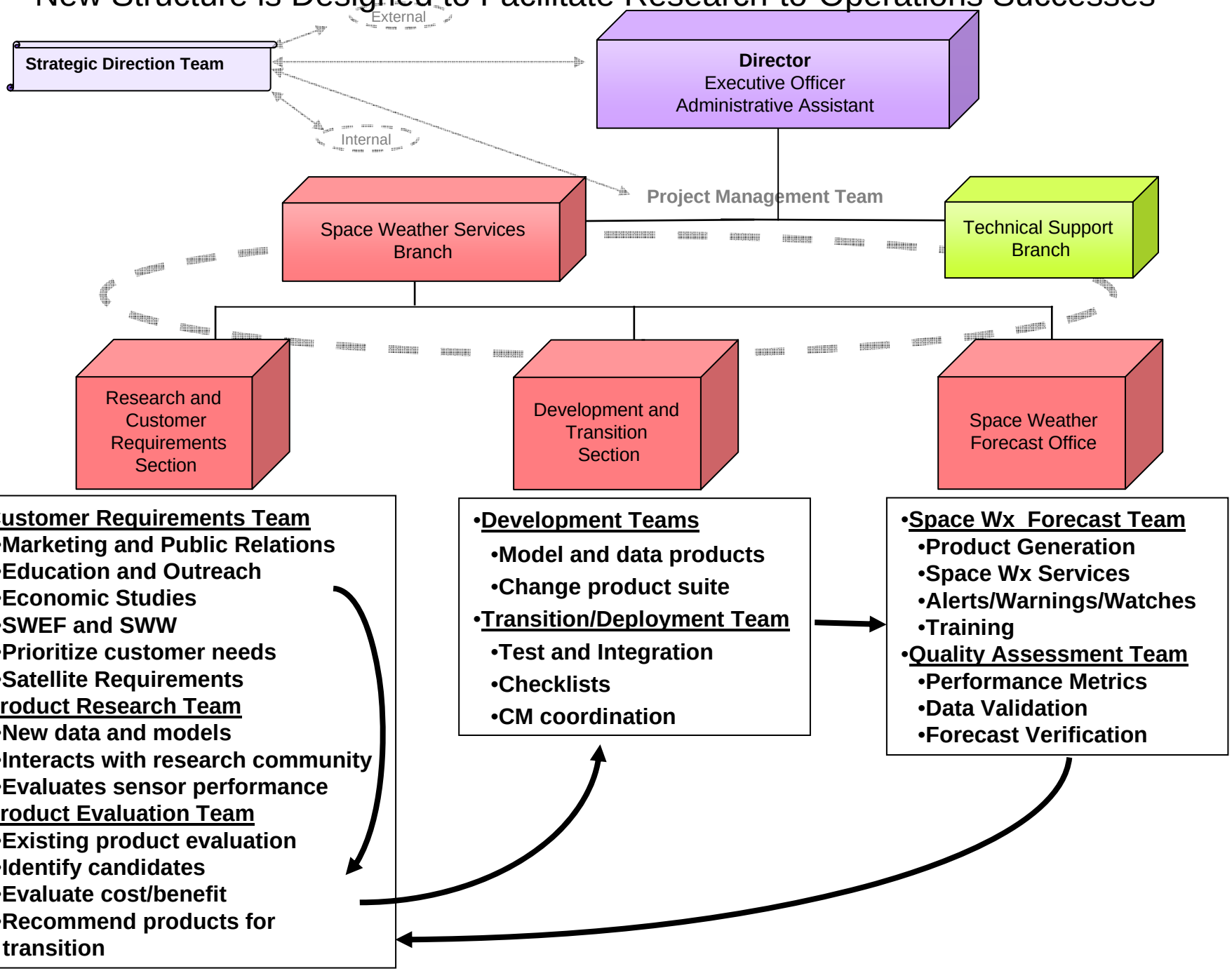
NOAA Space Weather Prediction Center-Research and Operations Collaboration

- SWPC orientation toward transition
- Customer needs and growth areas
- Core forecast products
- Defining current capabilities and needs



New Structure is Designed to Facilitate Research-to-Operations Successes

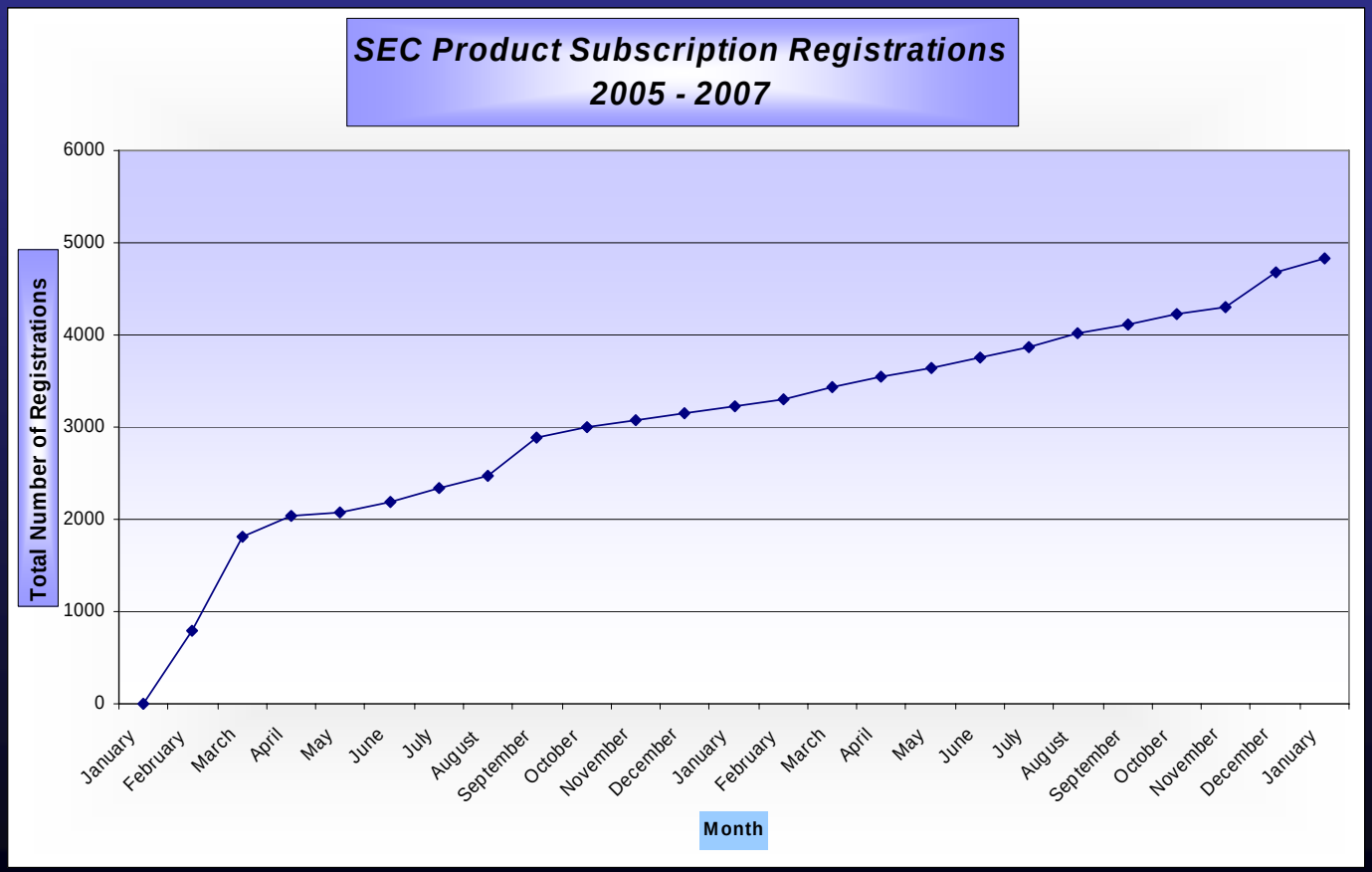


Space Weather User Community

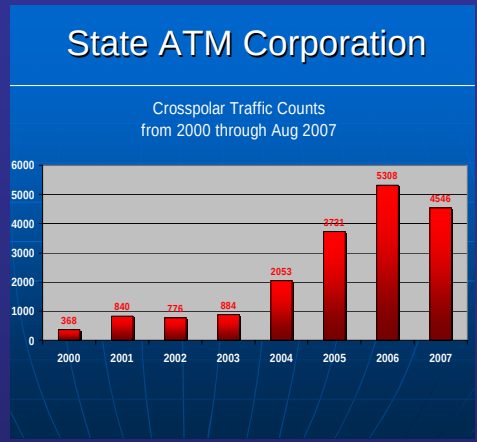
Impact Area	Customer (examples)	Action (examples)	Cost (examples)
Radiation dose (dose limits & health risks, possible acute effects for space exploration missions)	• NASA exploration • ISS • Space tourism • Airline crews/passengers	• Postpone activities • Seek shelter • Re-route flight paths	• Safety Issue • Health risks
Spacecraft (Individual systems to complete spacecraft failure; comm, drag, and radiation effects)	• Lockheed Martin • Orbital • Boeing • Space Systems Loral • NASA, DoD	• Postpone launch • In orbit - Reboot systems • Turn off/safe instruments and/or spacecraft • Maintain orbit	• Loss of spacecraft ~$500M • Commercial loss exceeds $1B • Worst case storm - $100B
Electric Power (Equipment damage to electrical grid failure and blackout conditions)	• U.S. Nuclear Regulatory Commission • N. America Electric Reliability Corp. • Allegheny Power • New York Power Authority	• Adjust/reduce system load • Disconnect components • Postpone maintenance	• Estimated loss ~$400M from unexpected geomagnetic storms • $3-6B loss in GDP (blackout)
Airlines (Communications) (Loss of flight HF radio communications)	• United Airlines, Continental, Lufthansa, Korean Airlines • NavCanada (Air Traffic Control)	• Divert polar flights • Change flight plans • Change altitude • Select alternate comms	• Cost ~ $100k per diverted flight • $10-50k for re-routes
Surveying & Navigation (Use of magnetic field or GPS could be impacted)	• FAA-WAAS • Dept. of Transportation • BP Alaska and Schlumberger • Fugro Chance – offshore oil rig	• Postpone activities • Redo survey • Use backup systems	• From $50k to $1 mil daily for single company

Recent Trends

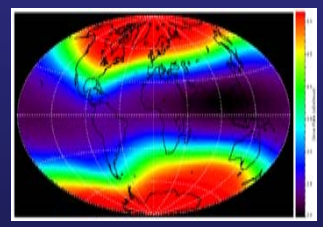
- **Steady overall growth of users**
- **Fastest growing user areas: GPS & Polar Aviation**



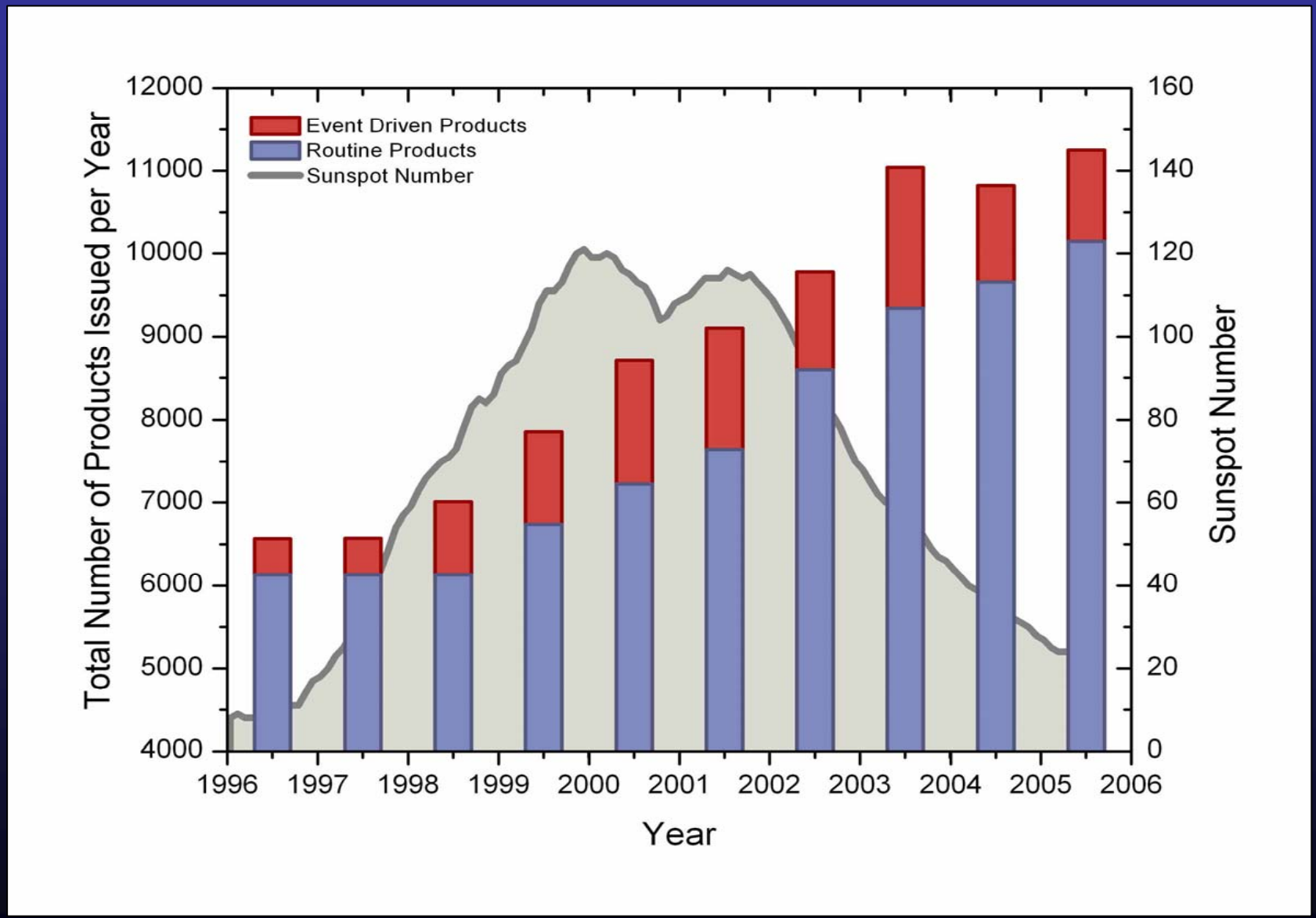
Recent Trends



- **Drivers for Polar Aviation**
  - **Flight time reductions of 1 to 3 hours**
  - **Absence of turbulence and convection**
  - **Availability of modern aircraft with 6k to 9k mile range**
  - **Economic growth of China and India**



- **Drivers for GPS market**
  - **Deep-sea drilling**
  - **Surveying**
  - **FAA navigation systems**
  - **DOD operations**
  - **Mining & Farming operations**
  - **Construction**

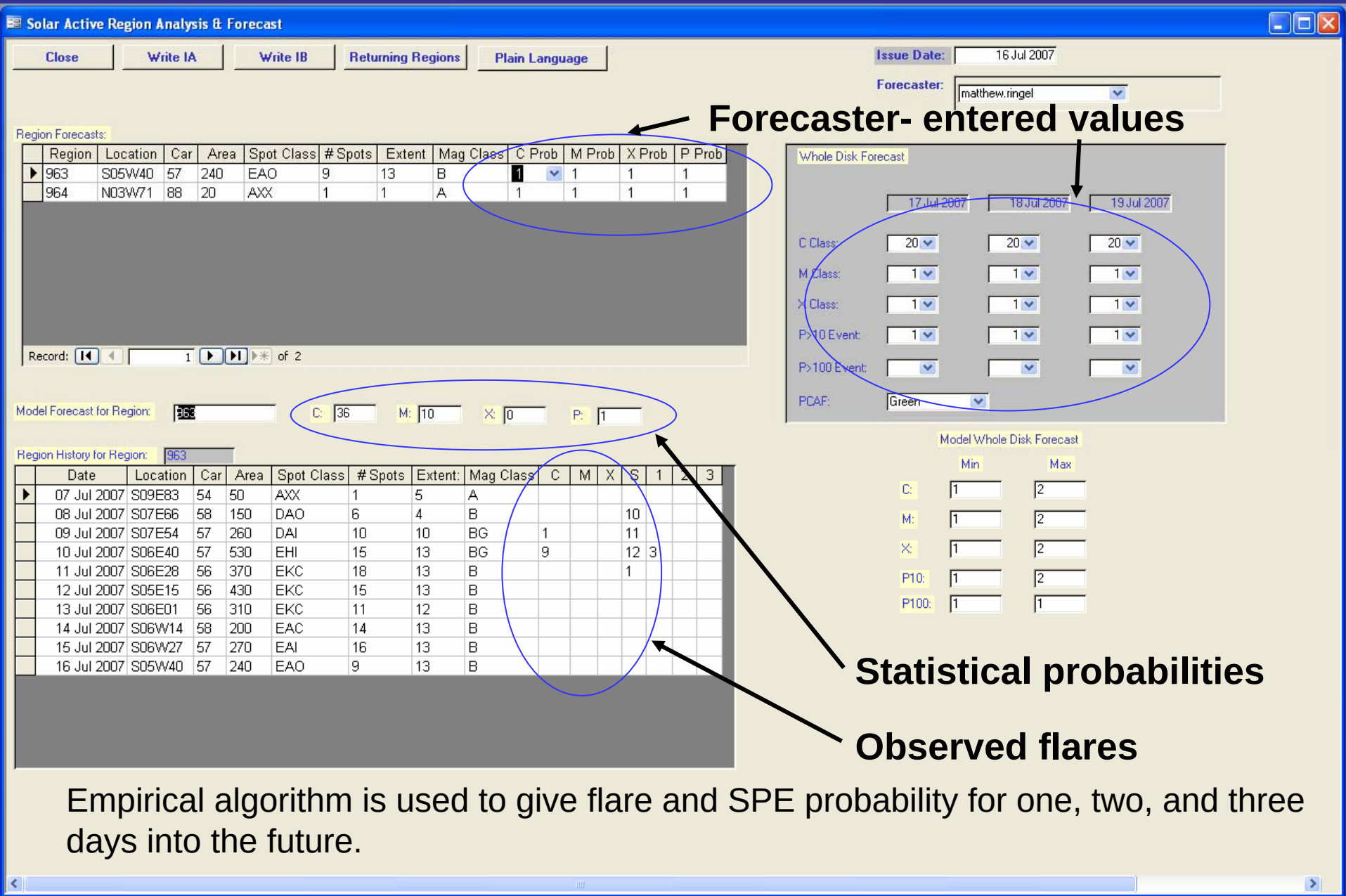

Event Driven Products
Routine Products
Sunspot Number
Total Number of Products Issued per Year
Sunspot Number
Year
12000
11000
10000
9000
8000
7000
6000
5000
4000
160
140
120
100
80
60
40
20
0
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006

Major Forecast Center Products

- Daily Forecasts:
  - Solar flares
  - Solar energetic particles
  - Geomagnetic activity
  - 10.7 cm radio flux

- Event-Driven Warnings and Alerts:
  - Warnings: geomagnetic storms, proton events
  - Alerts: solar flare, proton event, geomagnetic storm, electron event, solar radio burst

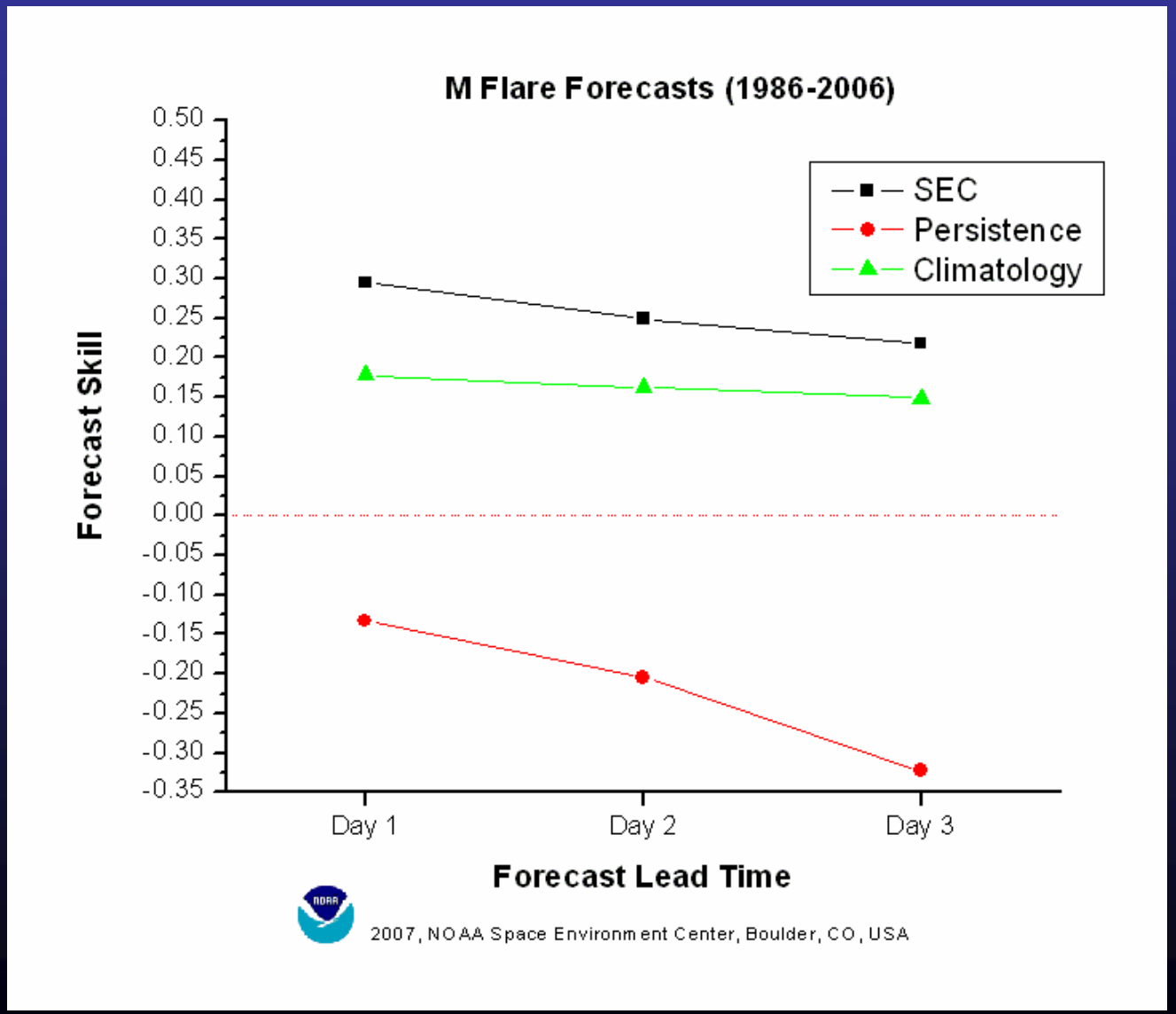
Solar Active Region Analysis Tool



Empirical algorithm is used to give flare and SPE probability for one, two, and three days into the future.

Forecast Skill by Lead Time

- This type of skill is also called “prediction efficiency” and measures how much of the the variance in the observations is captured by the forecasts
- SEC forecast skill decreases with longer lead time
- SEC forecasts are better than simple schemes
- Persistence flare forecasts have negative skill



Major Space Weather Customer Needs

- Communication outage probability
  - Solar energetic particle probability
  - Flare probability
- Ground dB/dt probability
- Human radiation exposure probability
- Satellite radiation exposure probability
- Ionospheric Total Electron Content probability

Summary

- Customer needs involve a wide range of impact areas, with different accuracy and lead-time requirements
- Current services include forecasts, alerts, warnings, model output, and data
- Ongoing verification provides forecast skill for many of our key products
- SWPC is working on quantifying what users need (what information and how good it has to be), quantifying how good our current products are, and communicating this to the scientists developing models. This will help scientists understand how good a model has to be in order for it to be useable by NOAA.