

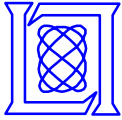
Exploiting AFSCN Ranging Data for Catalog Maintenance

A. J. Coster, R. Abbot, L. E. Thornton, D. Durand

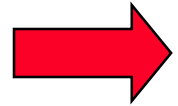
2001 Space Control Conference

3 April 2001

*This work is sponsored by the Air Force under Air Force Contract AF19628-00-C-0002
Opinions, interpretations, conclusions, and recommendations are those of the author
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OUTLINE



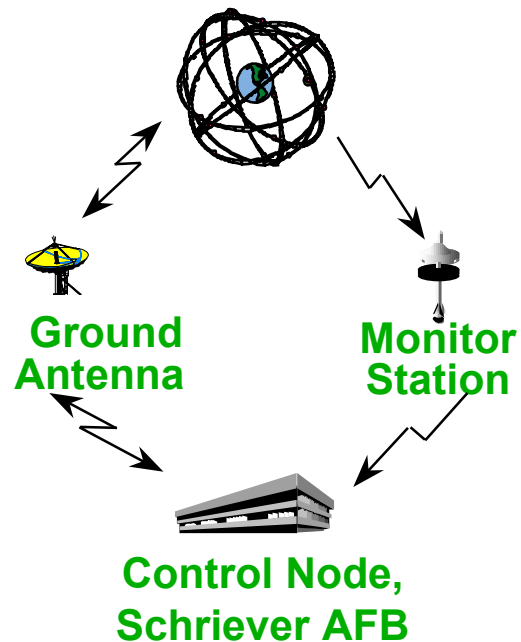
Introduction

- **Lincoln Experience with AFSCN data**
- **Calibration Issues**
- **Description of Project and Schedule**
- **Summary**





AFSCN: Air Force Satellite Control Network



Eight worldwide fixed remote tracking stations (RTS) hosting 15 antennas using the Space Ground Link Subsystem (SGLS).

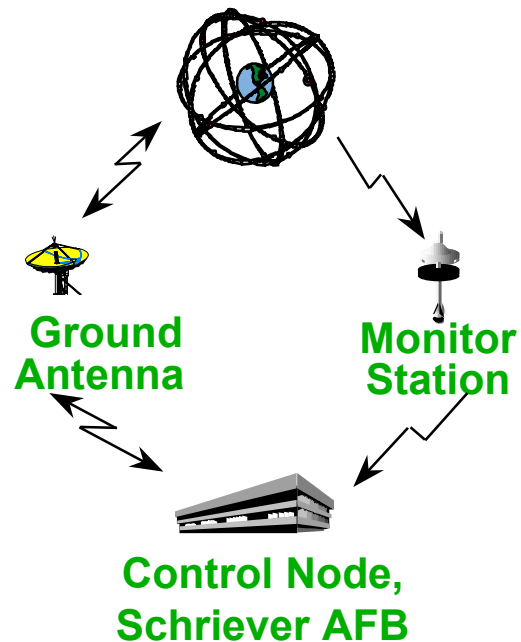
Two mission control nodes at Onizuka AFB, CA and Schriever AFB, CO



Measurement types: Range, Range-rate, Azimuth, and Elevation



AFSCN: Air Force Satellite Control Network



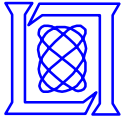
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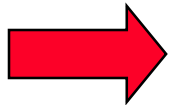
Measurement types: Range, Range-rate, Azimuth, and Elevation

AFSCN data not currently used by SCC for catalog maintenance



OUTLINE

- **Introduction**



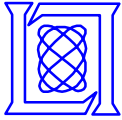
- **Lincoln Experience with AFSCN data**

- **New Boston Refraction Study (1993)**
- **MSX Satellite Ephemeris Prediction (1989-present)**

- **Calibration Issues**

- **Description of Project and Schedule**

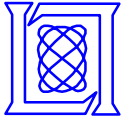
- **Summary**



New Boston AFSCN Calibration Study

- **Objective:** How to achieve high accuracy from SGLS data?
- **Method:**
 - Acquire and process New Boston tracking data from their SGLS/ARTS equipment on GPS satellite
 - Assess calibration
- **Result:**
 - Using the Millstone derived real-time troposphere and ionosphere values
 - Site bias of 57.8 m determined
 - 1.35 ms time offset correction and -1.1 m coordinate correction in z direction
 - Data accuracy = 0.77 m

One meter sensor data can be achieved using refraction corrections and GPS reference orbits

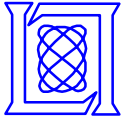


MSX Precision Ephemeris Generation

- MSX launched on 25 April 1996 into an 898 km orbit
- MSX carries the Space Based Visible (SBV) sensor
 - MSX serves as **observing platform**
- **Accuracy of sensor (SBV) measurements depends on position accuracy of MSX**
- Based on error budget for SBV measurement
 - Requirement for MSX position accuracy to be **< 15 m (1 sigma)**



MSX



MSX Precision Ephemeris Generation

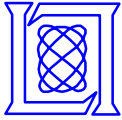
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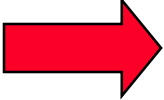
MSX

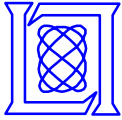
MSX orbit procedure based on AFSCN data developed that yields a post-fit satellite ephemeris accurate to **7 m.**

MSX orbits have been produced since 1996



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Importance of Calibrating AFSCN data

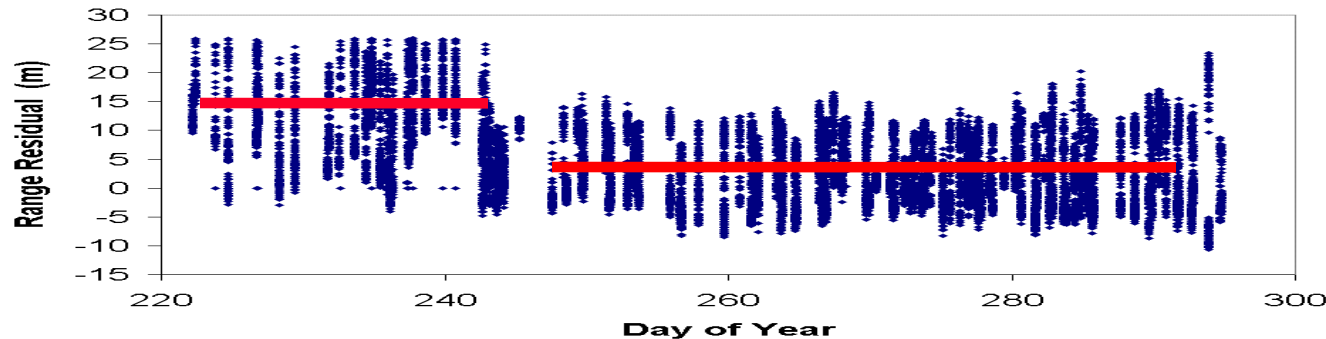
- Transponder biases are generally on the order of **300 m**
- Nominal site biases can be up to **600 m** and corrections to these can be up to 50 m and need to be constantly monitored



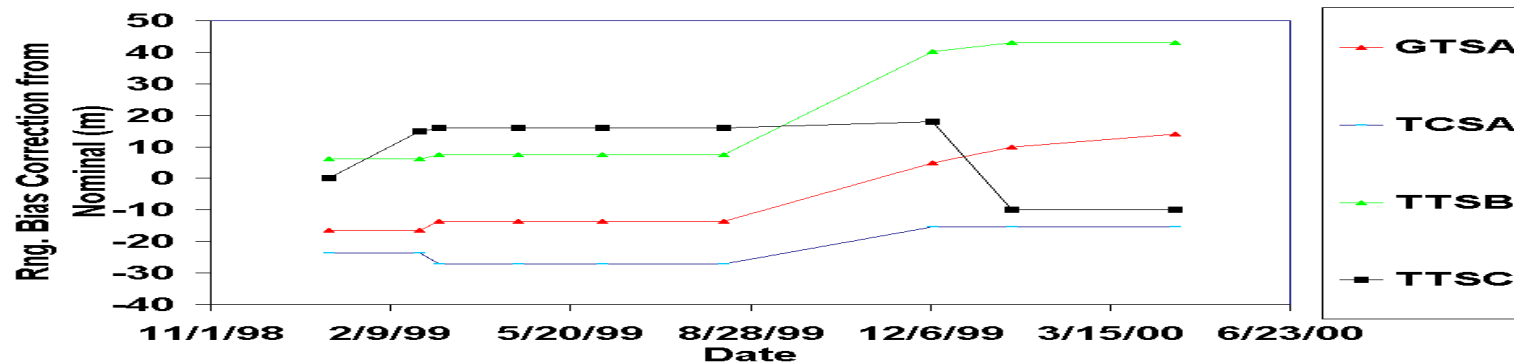
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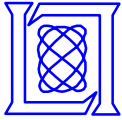
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SGLS Jump in Individual Site Bias



*SGLS Range Bias History: **Selected SGLS Sites** (11/99 – present)*





Models Evaluated for Troposphere (UNB4) and Ionosphere (IRI)

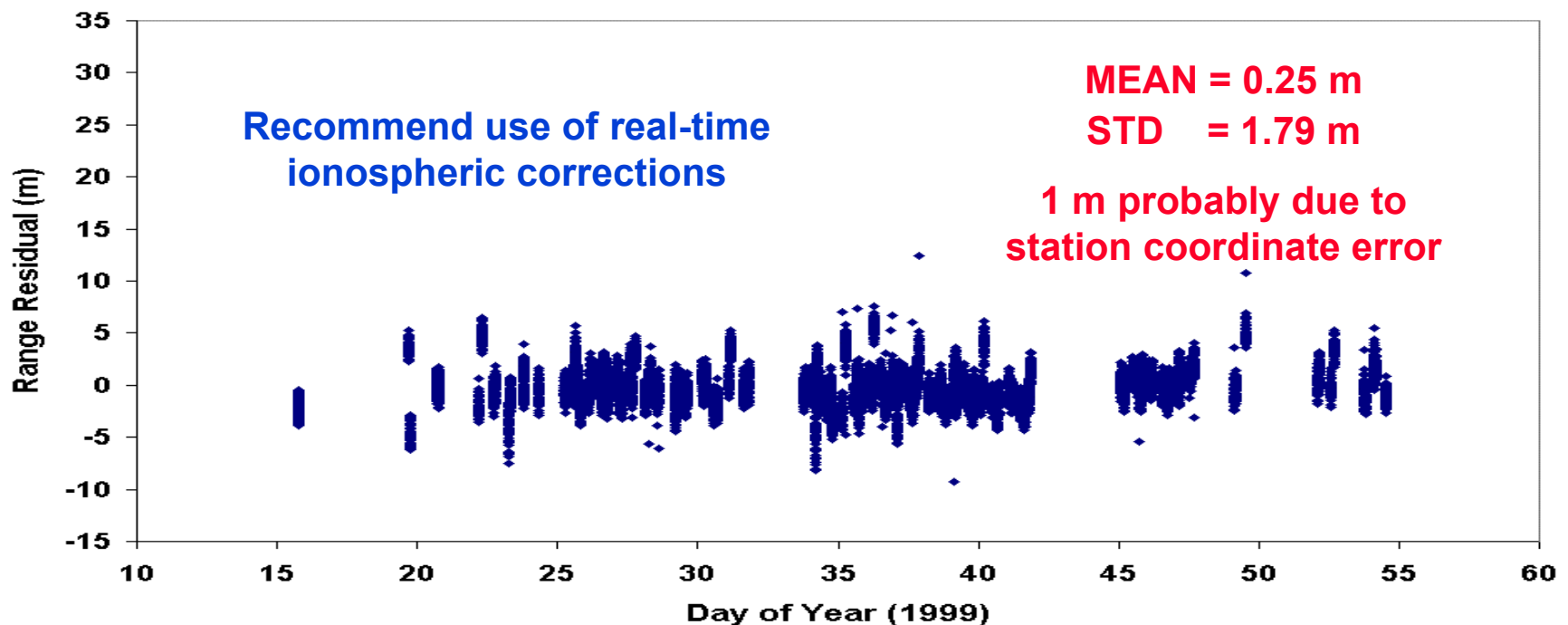
- The zenith tropospheric effect is 2.5 m and maps to **several hundreds of meters** at low elevations
- The ionospheric effect will be up to **20 m** at solar maximum depending on site and time of day

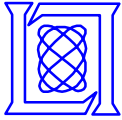


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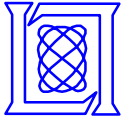
AFSCN Range Residuals on GPS Satellite



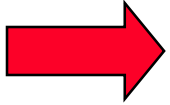


Summary of Lincoln Analysis of AFSCN Data

- **Bad estimates for the transponder and site biases will make the data useless**
- **Bad estimates of the atmospheric corrections will degrade its use.**
- **AFSCN data needs to be correctly weighted**
- **Calibrated AFSCN data are of high quality. Can be used to support special perturbations catalog.**
 - **Range (6 m)**
 - **Range-rate (3 cm/s)**
 - **Azimuth and Elevation (20 mdeg)**



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Statement of Work

ADCAT (AFSCN Data Calibration and Translation) Project

LL Project to build ADT (AFSCN Data Translation) workstation

- **Tasks**

- **Select AFSCN calibration satellites**
- **Develop and test calibration and reformatting software with AFSCN 1-sec message format**
- **Establish methods of data flow (in and out)**
- **Install turn-key workstation at Schriever AFB**
- **Monitor operation**



Possible Calibration Satellites

(to be used to determine site biases)

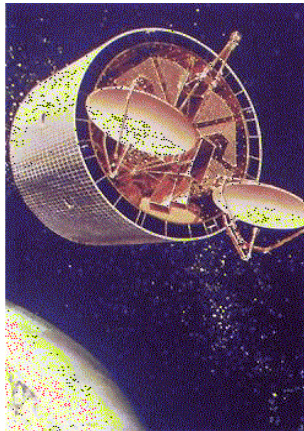


MSX: will be used



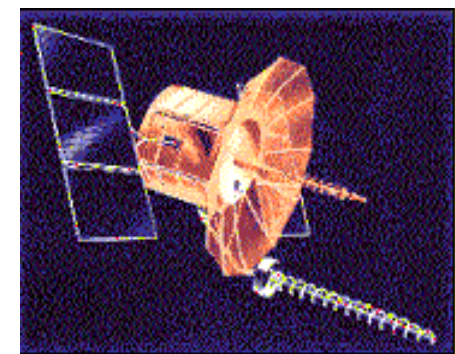
GPS

GPS data may be available
through 1SOPS

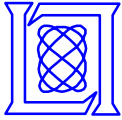


DSCS-2

**DSCS and
FLTSATCOM** are
possible candidates for
determining AFSCN
site biases.



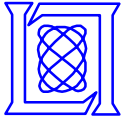
FLTSATCOM



Correlation Software Information

Correlation required because AFSCN 1-sec message format has no satellite ID.

- **Correlation Software options being analyzed. Possibilities include:**
 - Initial orbit determination using SWC's IOMOD
 - SWC correlation software is called ROTAS
 - MIT Lincoln's SATCOR (correlation software)
- **Documentation and a PC LINUX version of both IOMOD and ROTAS has been delivered to Millstone.**
- **Test plans being developed to evaluate the usability of these correlation routines for this project.**



Communication Issues

Data communication between sites is being worked on. This is the most critical issue in this project.

PRIMARY

- **AFSCN data into workstation at Millstone. Require comm link between Schriever AFB and Millstone for the AFSCN 1/sec message data**

Initial POCs established between 50 SW and Hanscom AFB

Link between Hanscom AFB and Millstone exists

- **Reformatted and calibrated AFSCN data into SPADOC**

Initially will be sent via regular Millstone obs route

- **Link between Millstone and Colorado Springs Workstation**

Used to send updated calibration coefficients, elements sets, and other ancillary data

SECONDARY

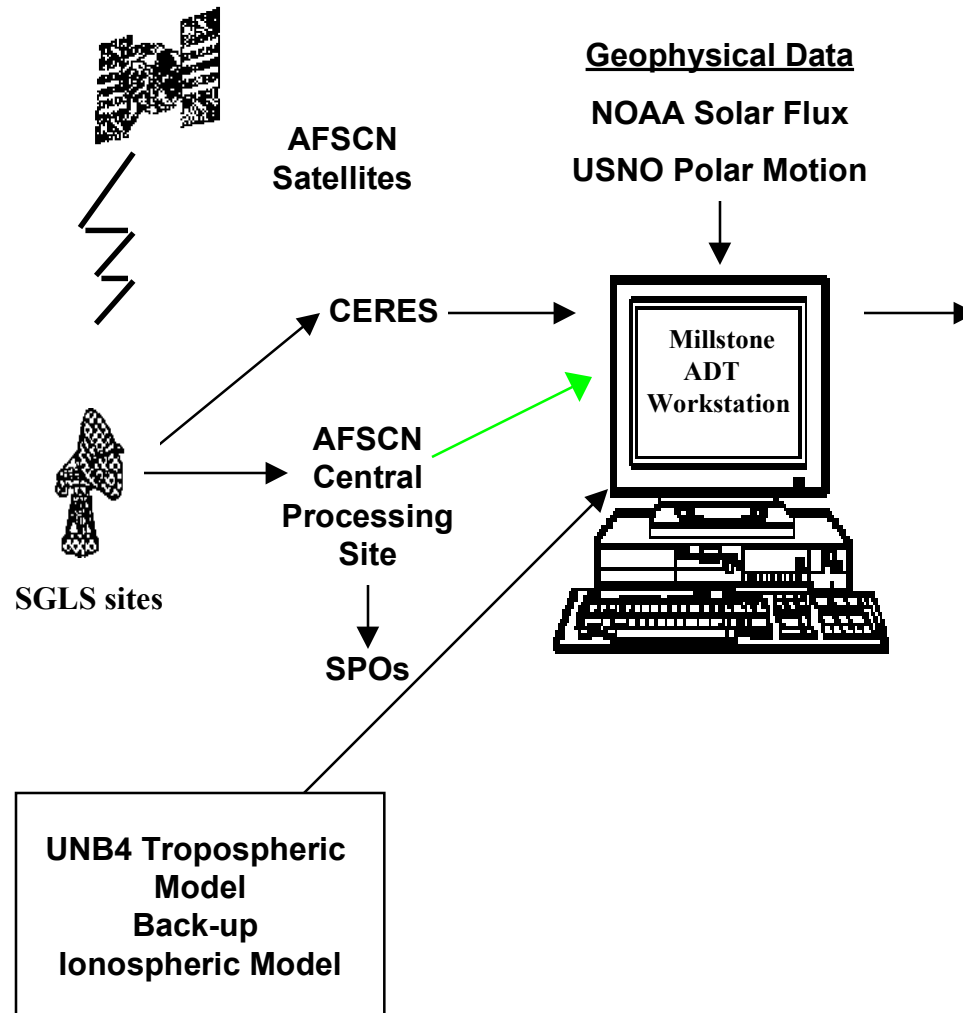
AFSCN data back to Millstone (Manual OBS-TRAN?)

Real-time ionospheric data into workstation



MIT Lincoln Laboratory AFSCN Project

FY01



Produce and apply estimates for:

- Site and transponder bias corrections
- Atmospheric delays and refraction

Data reformatted for SCC

Evaluate

- Best calibration satellites
- Ionospheric and tropospheric models

Develop

- Calibration Procedures

Process Real-time observations

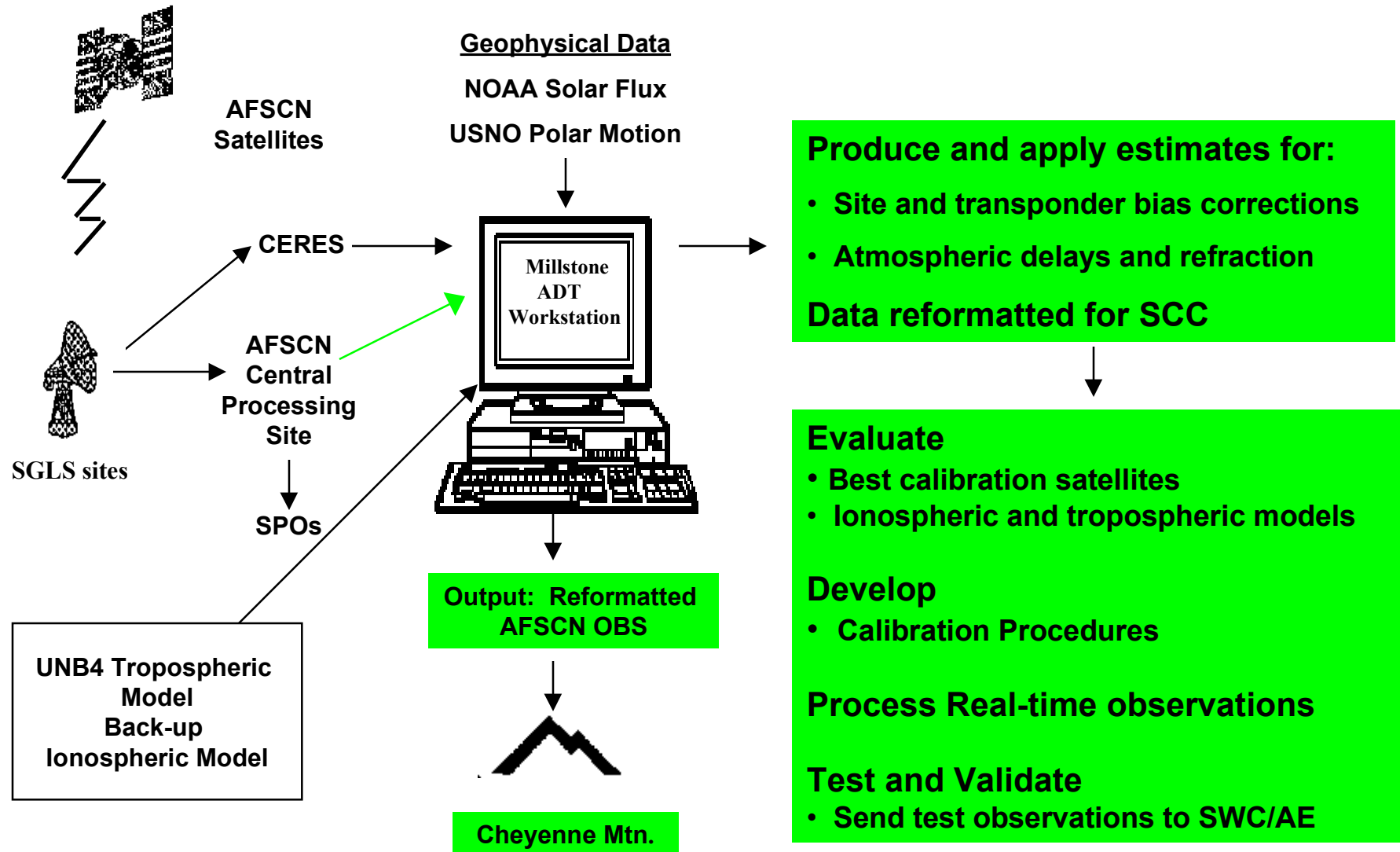
Test and Validate

- Send test observations to SWC/AE



MIT Lincoln Laboratory AFSCN Project

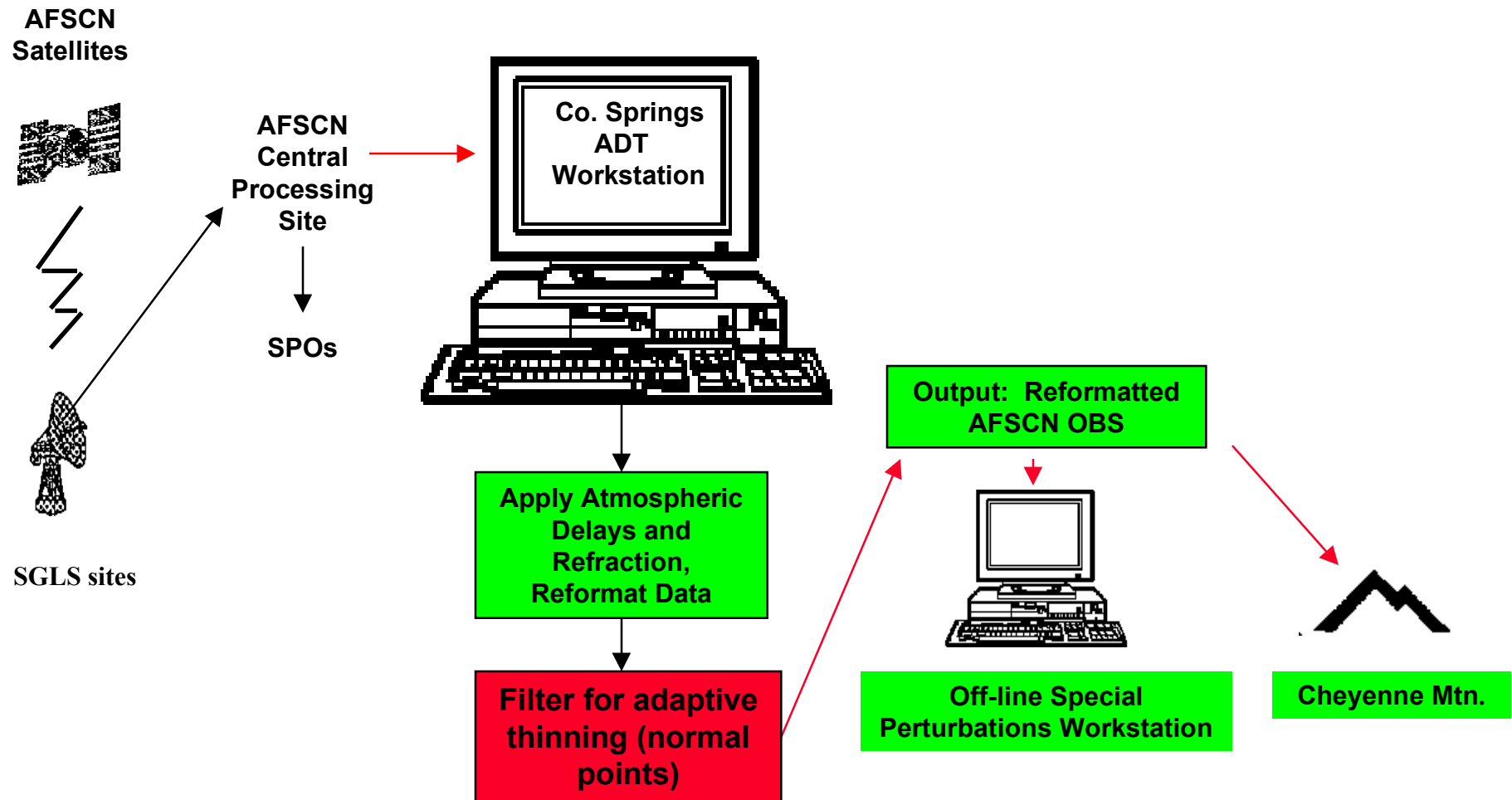
FY01





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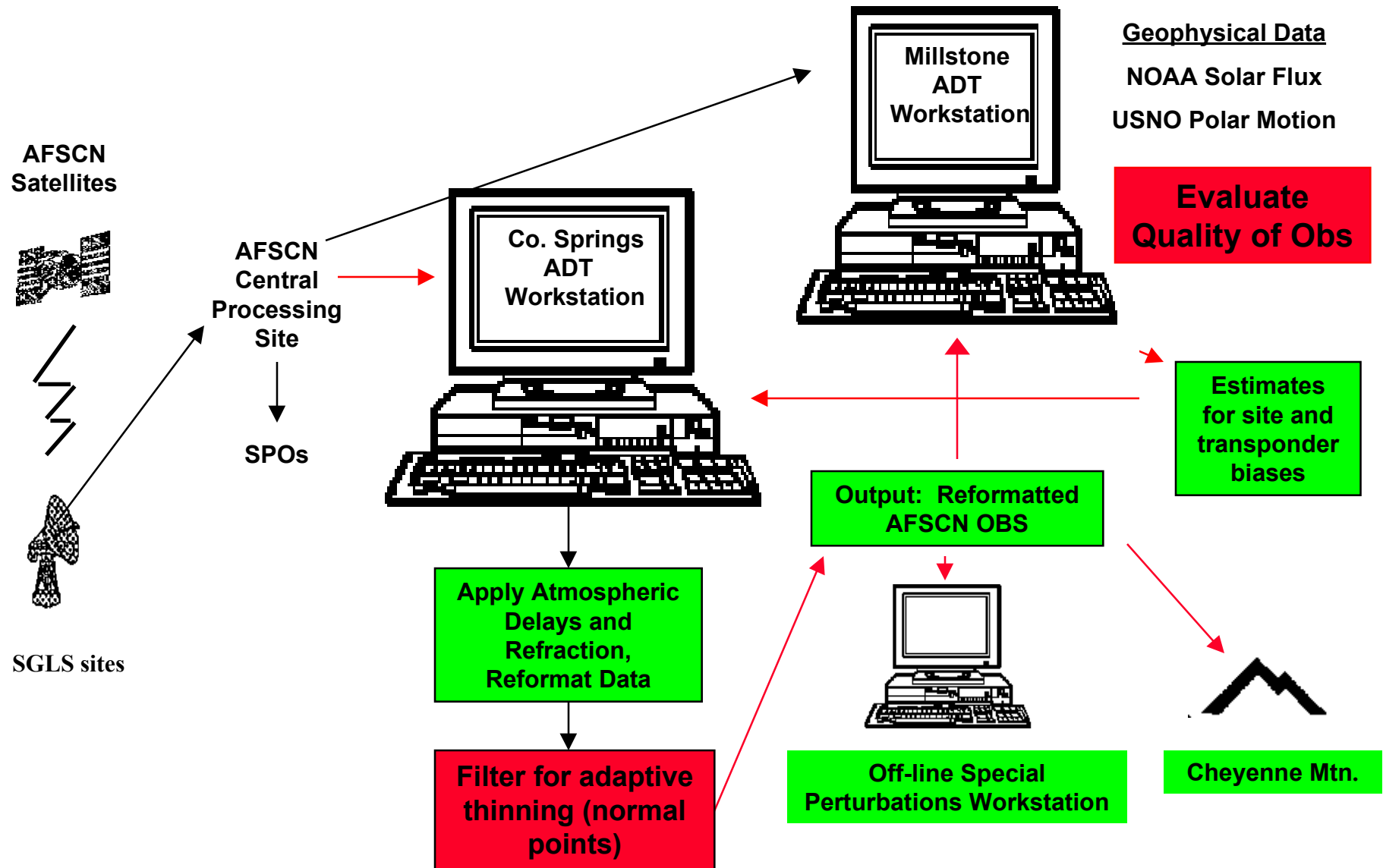
FY02

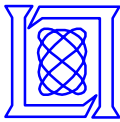




MIT Lincoln Laboratory AFSCN Project

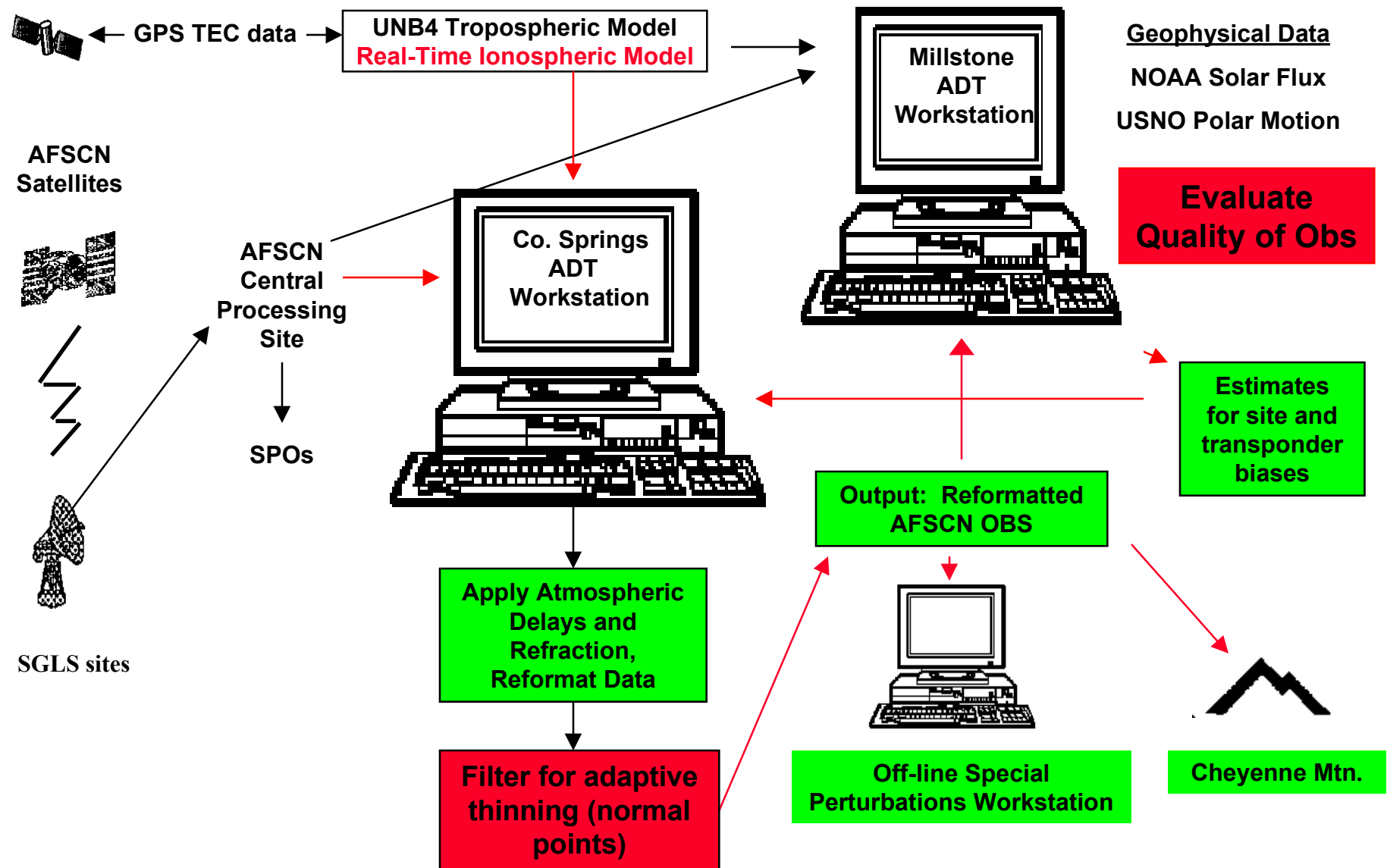
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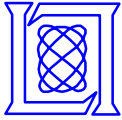




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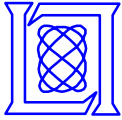


Current Data Analysis: Orbit Accuracy Improvement

Orbit Accuracy Assessed by Orbit Overlap for DSCS

	Total Range Error RMS (m)
Without SGLS	1343
With SGLS	288

SGLS data sampled every 30 s and assigned 10 m error



Summary

- **MAJOR OBJECTIVE**
 - Obtain all SGLS data, calibrate, reformat, and make available to Space Command
- **Communication links between LL, AFSCN, and Space Command are currently being established with the support of 50th SW and DOYS.**
- **Calibration procedures are being refined. Software has been developed and is being moved to the Linux workstation.**