ILRS Mission Support

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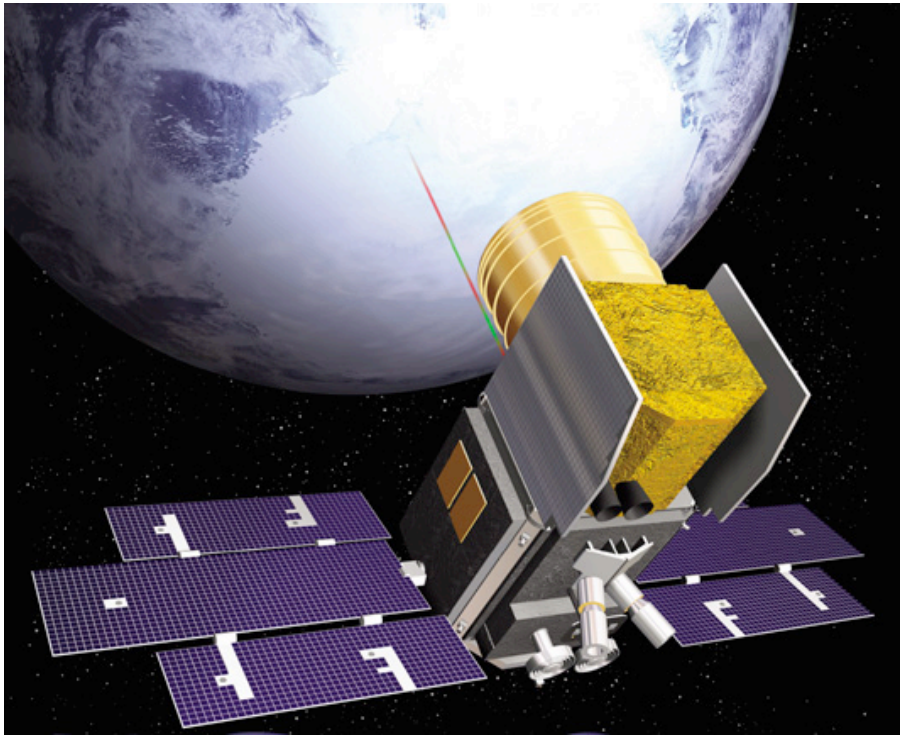
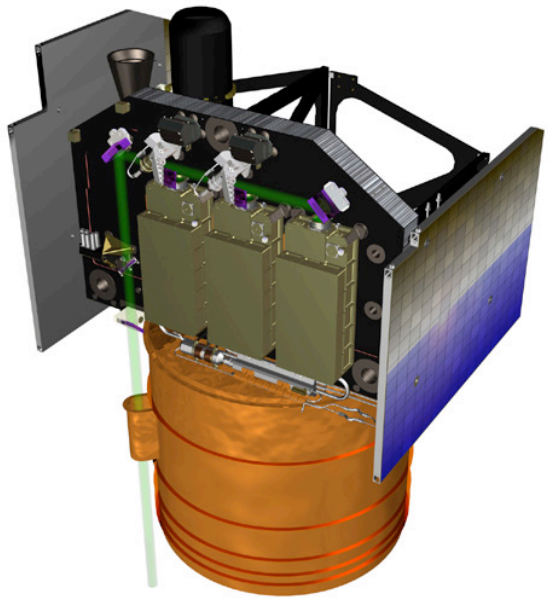
ICESat



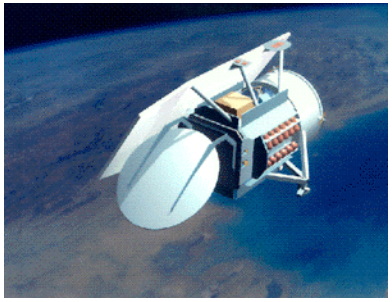
- NASA mission
- New geodetic tool to support multidisciplinary studies, including cyrosphere, atmosphere, hydrology
- ICESat operated in near repeat ground track
  - Orbit maneuvers ~ 8-10 days
  - Off-nadir pointing at reference ground track in polar regions

Geoscience Laser Altimeter System



- Three lasers to meet mission lifetime
- 1064 nm surface altimetry; 532 nm atmospheric backscatter
- Laser characteristics
  - Divergence illuminates ~70 meter spot on surface
  - 40 Hz pulse repetition rate
  - 170 meter spot separation
- Laser #1
  - 36 days in Feb-Mar 2003 (8-day repeat orbit; 4+ cycles completed)
- Laser #2
  - 56 days in Sept-Nov 2004
    - One 8-day repeat cycle
    - 48 days of 91-day repeat cycle
  - 33 days in Feb-Mar 2004 (91-day repeat)
  - 33 days started May 18 (91-day repeat)
- Laser #3
  - Operate in Fall 2004
- As of May 20, 2004:
  - 125 days of laser operation
  - 425 million laser shots
- SLR
  - measurements from: MLRS, GSFC, Zimmerwald
  - Tracking restrictions (track when elevation is <70°)

Image from: http://gfo.bmpcoe.org/Gfo/default.htm

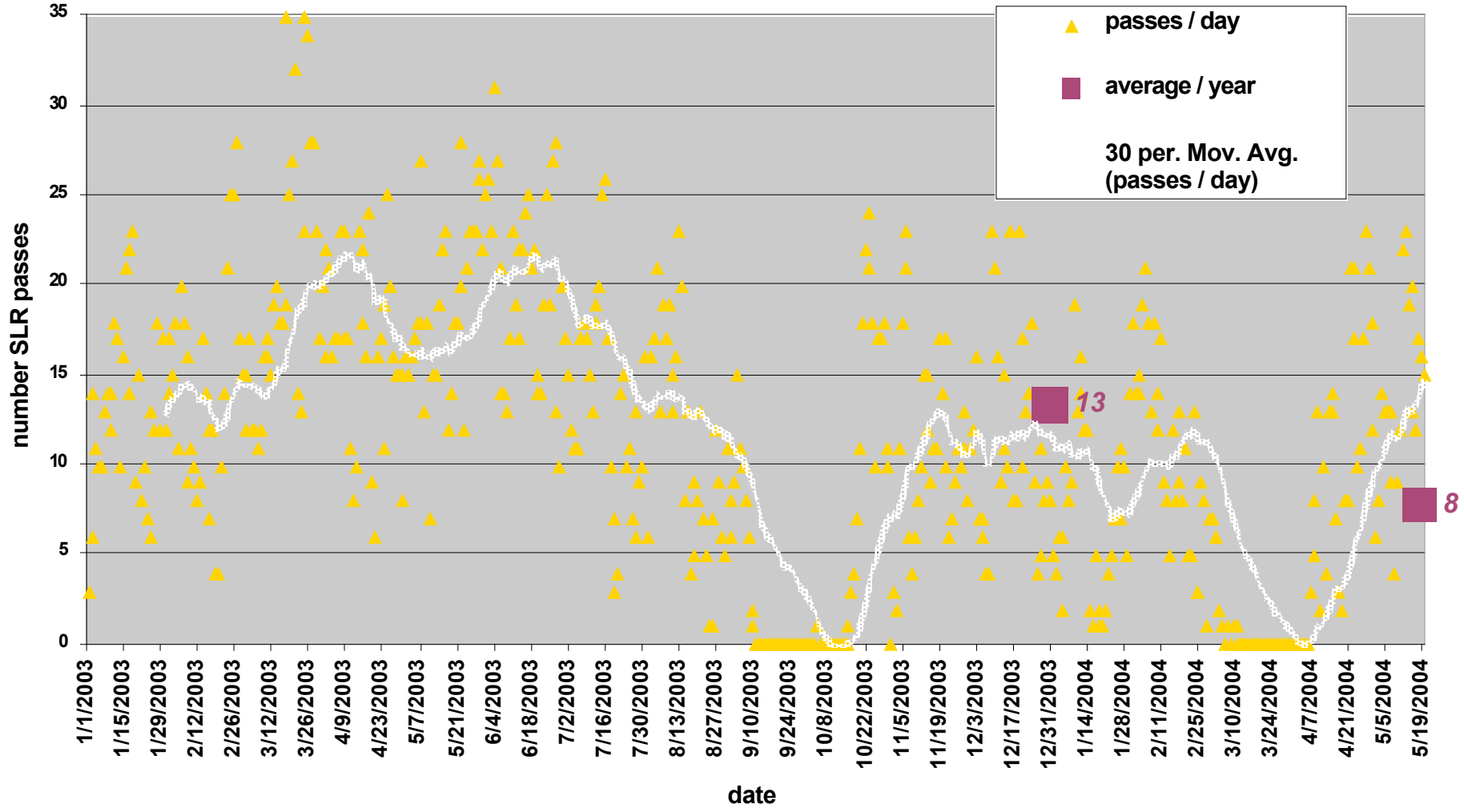


GFO Status

F. G. Lemoine, N. P. Zelensky, D. D. Rowlands
NASA Goddard Space Flight Center
June 2004

- GFO has exited solstice hiatus (Feb-April 2004) and normal operations have resumed.
- GSFC Code 926 now delivers tuned SLR predicts daily (since January 2004). [Thanks to Herstmonceux and Yarragadee for their help in refining our procedures].
- A new set of precise orbit ephemerides have been computed using a tuned CHAMP+GFO+other satellite geopotential model and will be delivered shortly to NOAA. Usable altimeter data now spans four years.
- Both the daily orbits (MOE's) and the precise orbits (POE's) depend heavily on SLR. Altimeter crossovers and Doppler are not enough! SLR continues to assure mission success. More tracking is encouraged.

GEOSAT Follow-On (GFO) SLR tracking / daily passes



ERS-2 Mission Status, Role of SLR

ERS-2 Mission Status

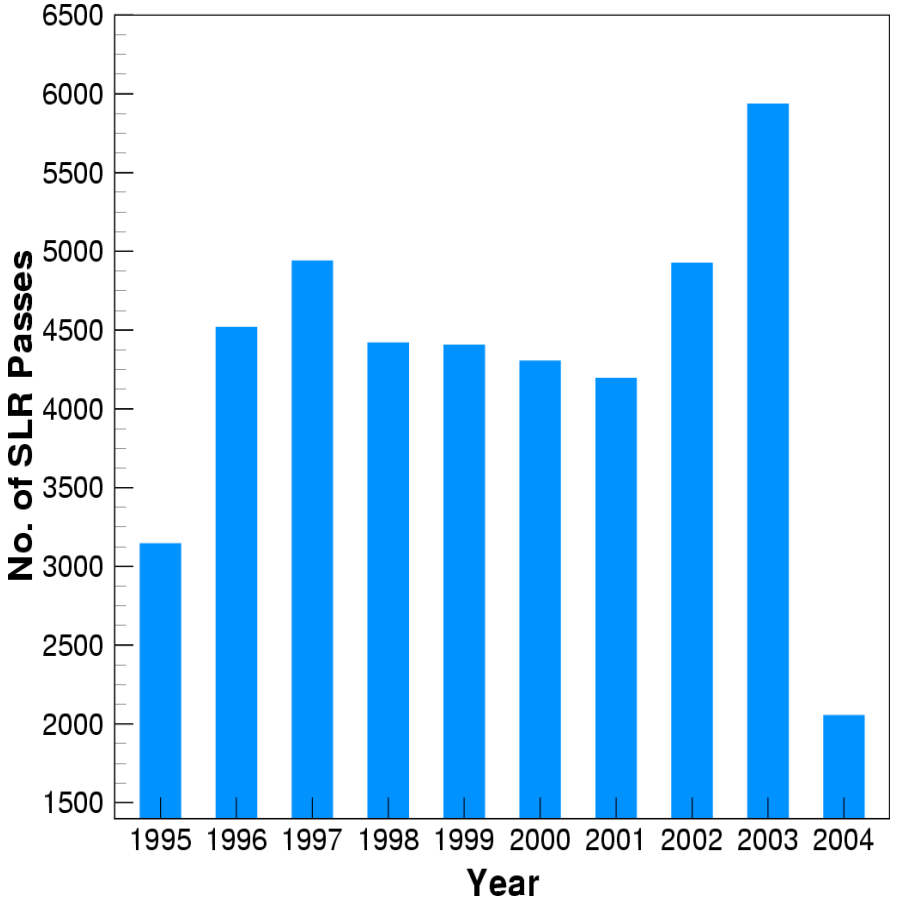
- ERS-2 is now in orbit for more than 9.0 years and operating longer than ERS-1.
- In general the satellite and the payload are in good condition.
- ESA plans to operate ERS-2 throughout 2005 (funding till mid 2005).

Role of SLR

- SLR is the secondary tracking system, while PRARE is the primary one.
- Since 2003 the PRARE system is operated by GFZ on best effort basis due to stop of funding by DLR. This results in an increasing importance of SLR.
- Intensive ERS-2 SLR tracking will be required throughout 2005.

ERS-2 SLR Data Quantity and Quality

- Since 2001 the SLR tracking steadily increased, 2001 showing the lowest, 2003 the best since start of the mission
- The data quality is in general very good
- Still sometimes large outliers when the normal point has been formed from one full-rate observation only



International Laser Ranging Service

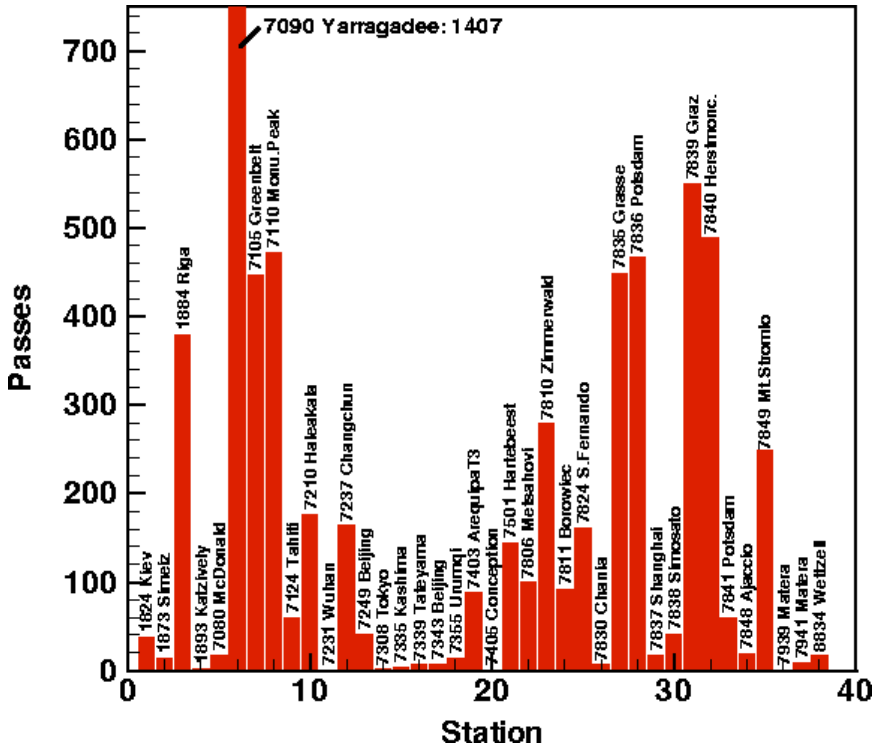
Role of SLR Data for CHAMP

- GFZ orbit predictions are based on ephemeris from GPS navigation solution **and** the more accurate SLR data.
- Routinely used for the validation of the data of the onboard GPS receiver in POD.
- SLR data serve as independent quality measure of gravity field models derived from CHAMP microwave tracking data.
- CHAMP SLR data are combined with GPS ground and space-borne observations for studies of temporal variations of the long wavelength part of the gravity field and the reference frame.

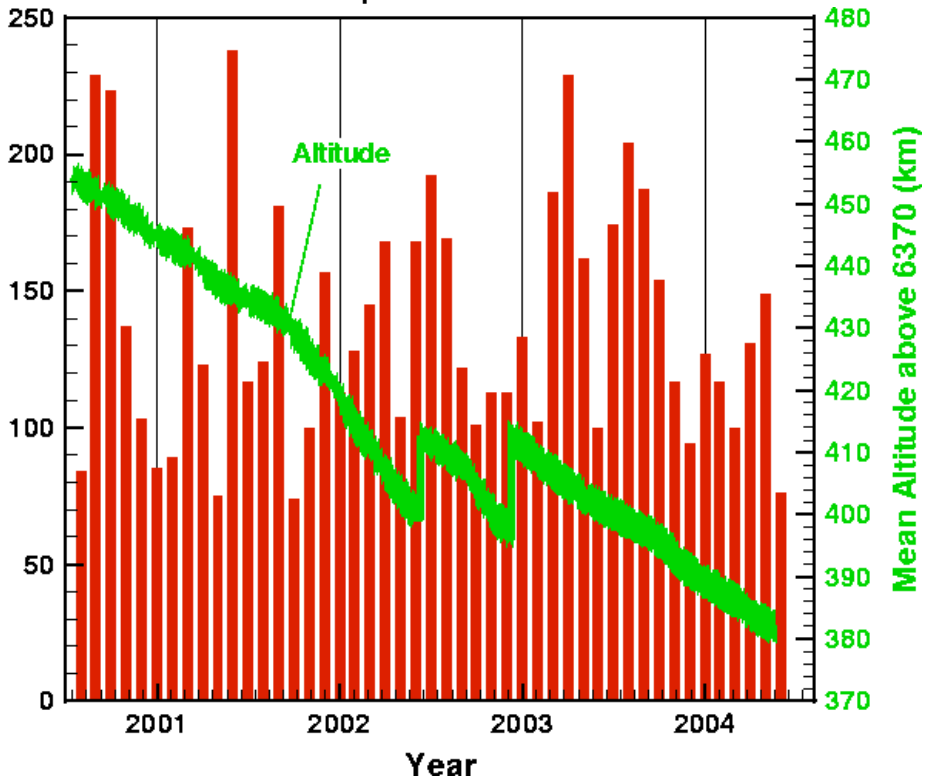
International Laser Ranging Service

CHAMP SLR-Tracking Jul. 2000 - May 25, 2004

Total per ILRS station



Total per Month



International Laser Ranging Service

CHAMP Summary

- Overall tracking statistics are quite satisfactory for the CHAMP mission - in particular in view of the low altitude of CHAMP.

- Recent statistics (first half of 2004) indicate that current procedure of 3 predictions/day is still sufficient. However, in view of the decreasing altitude an increase to 4-5 predictions/day might become necessary in future.

- SLR data plays an important role:

  - for the generation of accurate orbit predictions,
  - for the continuous validation of the microwave tracking systems onboard the CHAMP satellite,
  - for the quality control of gravity field modeling, and
  - for the combination with GPS data for reference frame and temporal gravity issues

= > continued intensive SLR support is requested

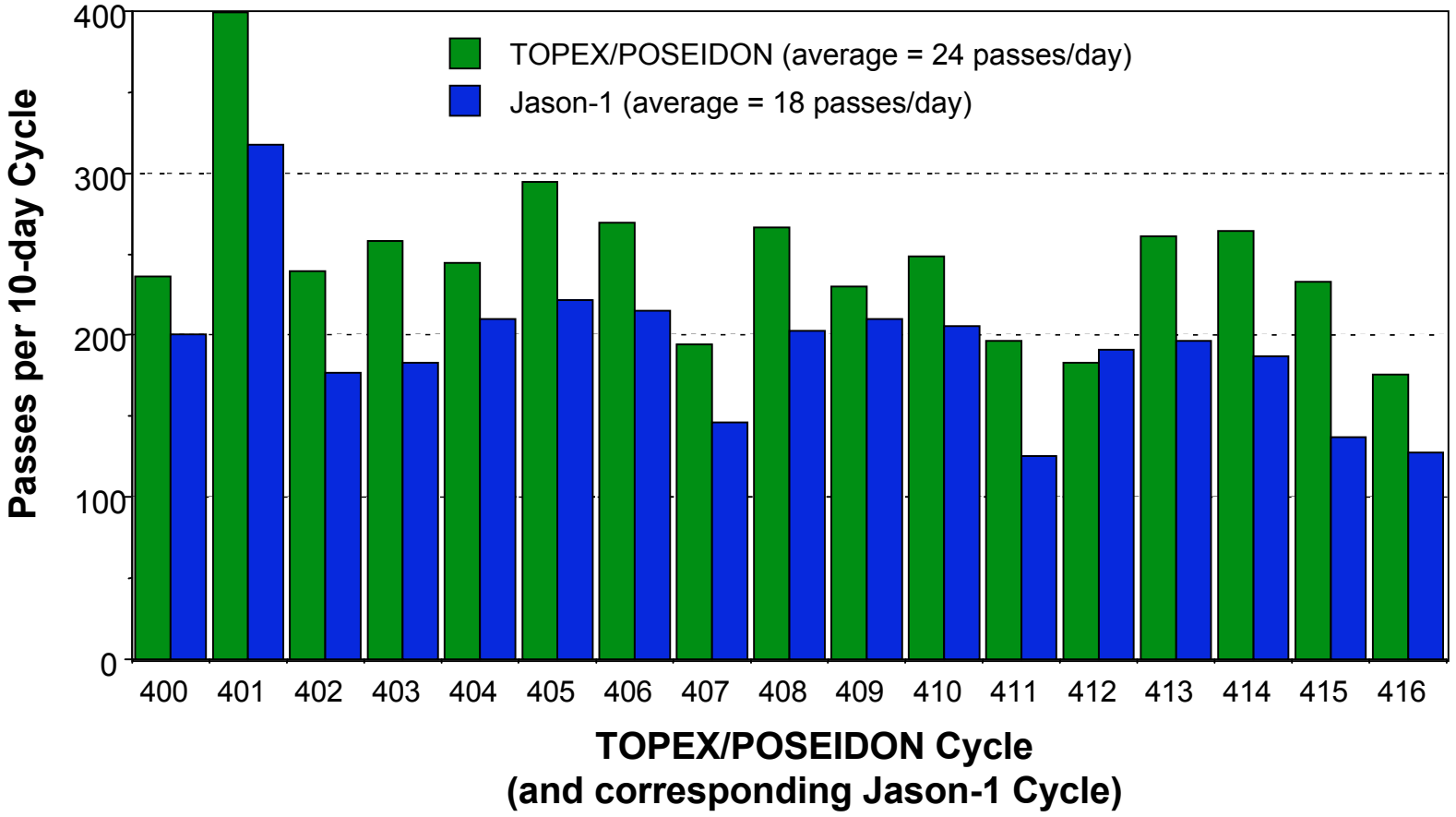
SLR Performance on TOPEX/Poseidon and Jason-1

- **Tracking of T/P and Jason-1 continues to meet mission goal of 15 good passes/day**

TOPEX/Poseidon		Jason-1	
Average number of passes/day	Fit RMS (mm)	Average number of passes/day	Fit RMS (mm)
24	22	18	17

- **Coverage is good in spite of close proximity of T/P and Jason-1**
  - **No significant change from previous report**
- **Tracking bias in favor of T/P likely due to much larger LRA**
  - **However, Jason-1 LRA design supports higher precision ranging**

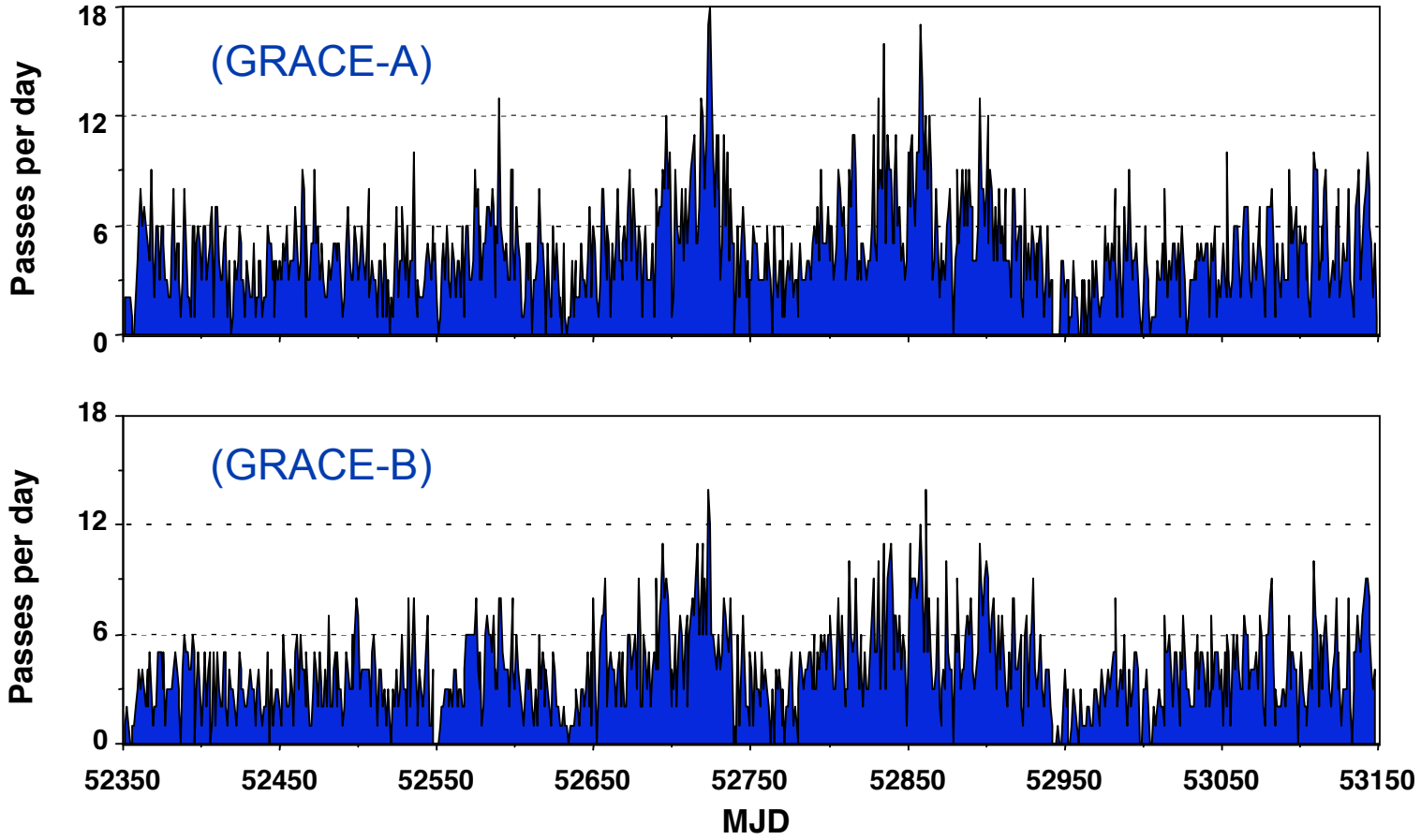
Most Recent SLR Tracking of T/P and Jason-1



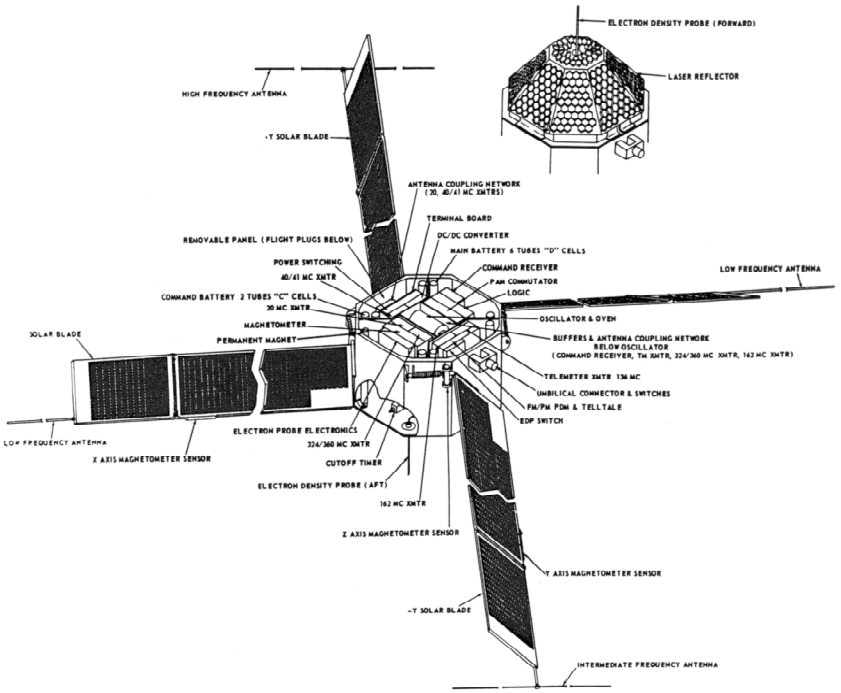
SLR Performance on GRACE

- GRACE-A and GRACE-B tracked ~4-5 times per day on average
  - GRACE-A tracked about 15% more often than GRACE-B
- 6-7 cm SLR RMS consistent with expected orbit error
  - Adequate for initial orbit quality assessment
- Z-bias in center-of-mass offset correction not fully resolved yet

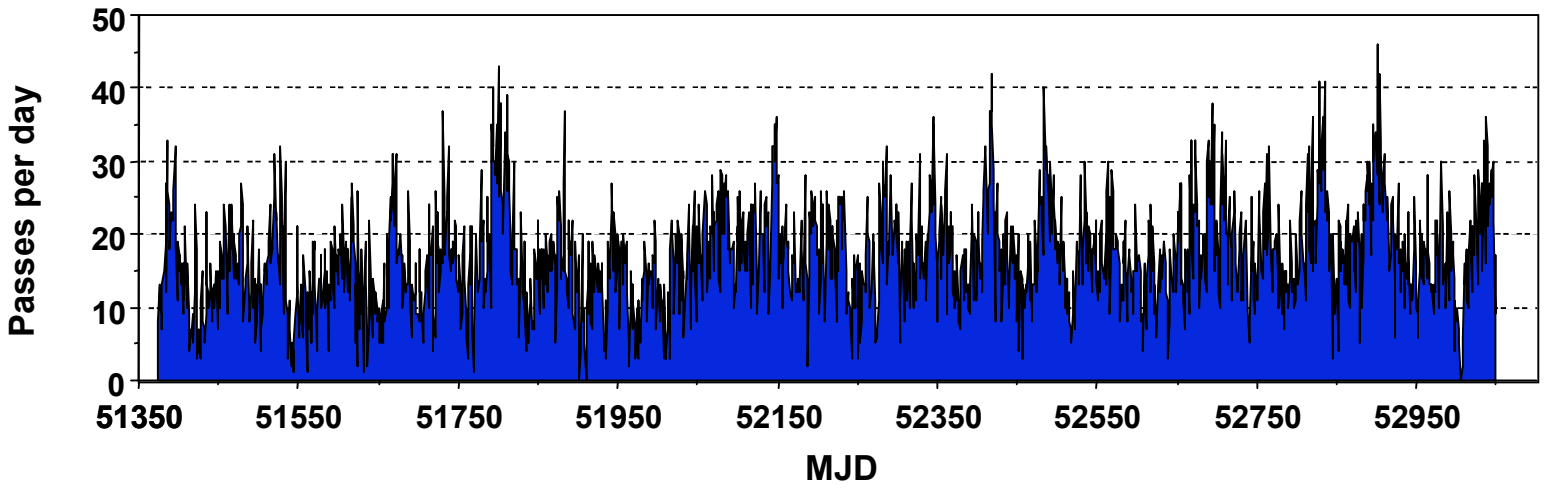
Gravity Recover and Climate Experiment (GRACE)



Beacon Explorer-C



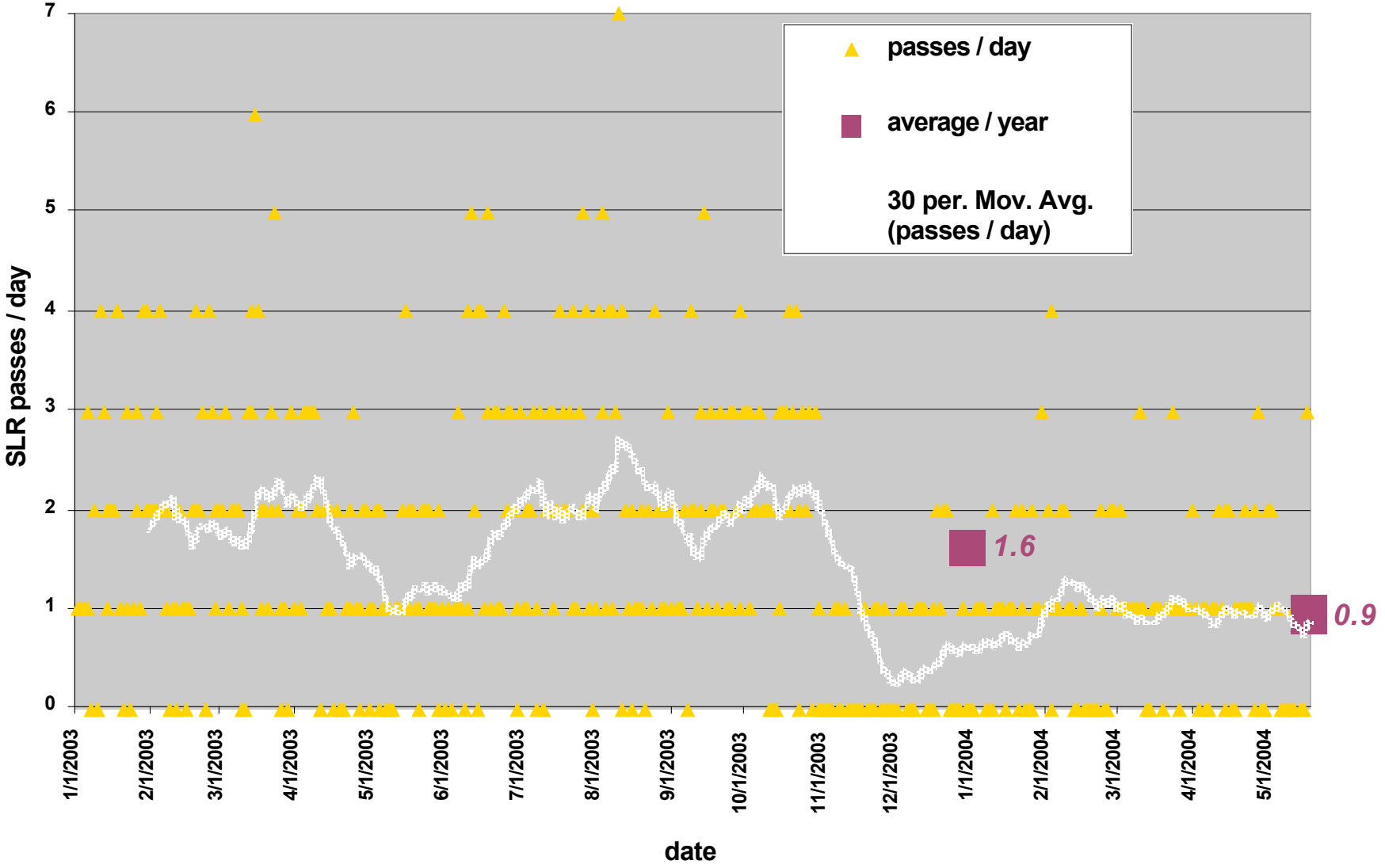
- BEC tracking used with Lageos-1 and 2, Starlette, Ajisai, and Stella for temporal gravity variability studies (Cheng et al., 2002)
- Average of 17 passes per day from 42 stations (after editing)
  - Weighted RMS of fit ~9.5 cm, ranging from 4 to 26 cm



Meteor-3M

- SAGE III/Meteor3m is a joint partnership of NASA and RASA
- Payload is SAGE III; measures temperature and humidity profiles and Earth Surface Properties (need good along-track orbit accuracy)
- Orbits NEED to be good to 500 meters along track
  - Benefits from improvement to 10s of meters
  - On board GPS receiver failed
  - SLR tracking has saved the mission
- Achievements:
  - Has extended the climate record of ozone aerosol and NO2 profile
  - Ground breaking measurements of NO3 from limb sounding
  - Preparation for next generation ozone monitoring (NPOES)
- SLR Tracking:
  - Has saved mission, but is often tracking is very sparse
  - Only a few stations track
    - Yaragadee (especially consistent)
    - Riyad, Herstmonceux, and Monument Peak

Meteor-3M (M3M)
SLR Tracking / Daily Passes



Summary

- SLR remains a important component of radar altimeter satellite POD, for accurate orbit centering (when used for orbit determination) and radial orbit accuracy assessment
  - Tracking on T/P and Jason-1 remains adequate
- Long-term long-wavelength temporal gravity variations can only come from SLR tracking of geodetic satellites
  - GRACE will determine higher resolution gravity variations but only for the duration of its mission
- Orbit accuracy assessment is particularly critical for missions such as GRACE and ICESat where no other independent, absolute orbit error assessment is available
- GP-B will be first SLR-tracked fully drag-free satellite
  - Should provide interesting analysis opportunities