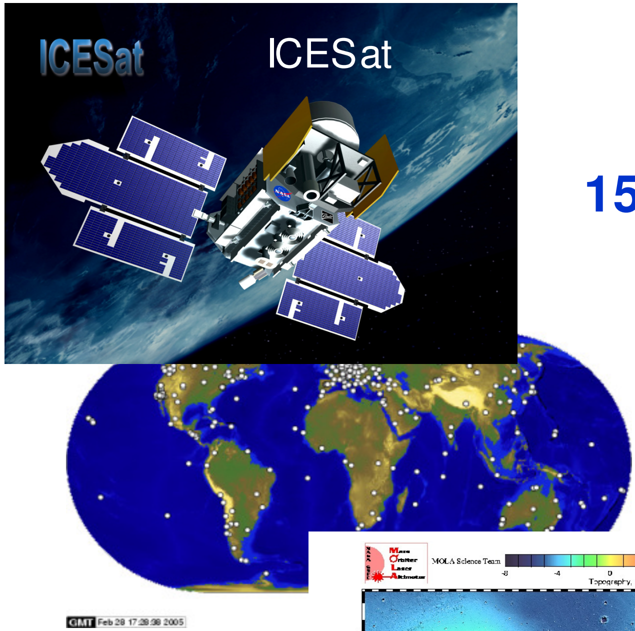
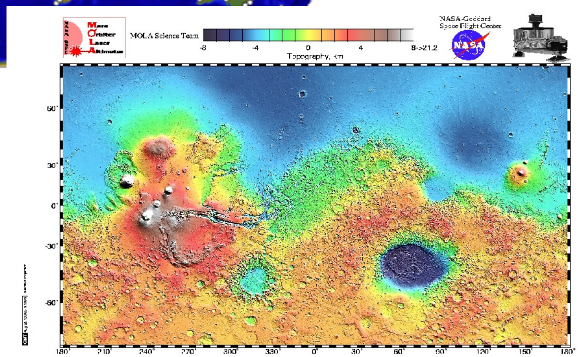
SCIENCE PRODUCTS

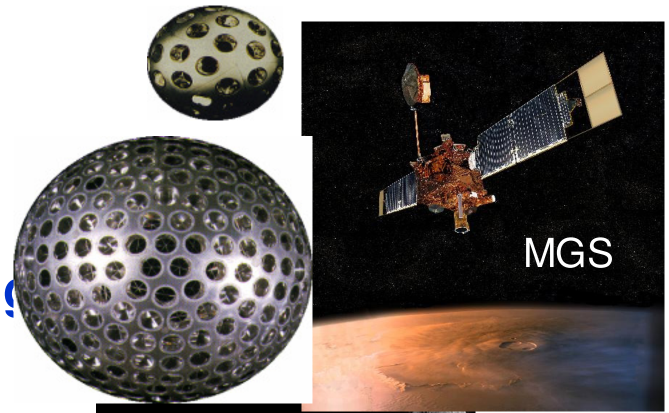


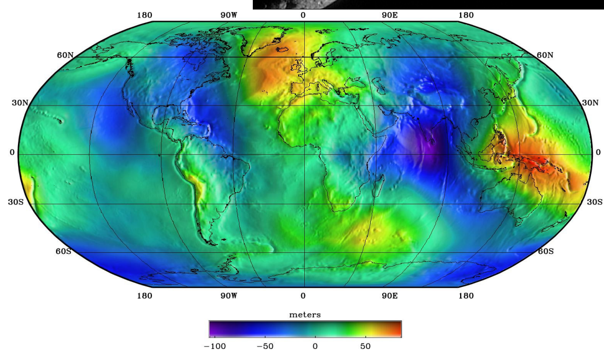
15th International Laser Ranging Workshop

Canberra, Australia

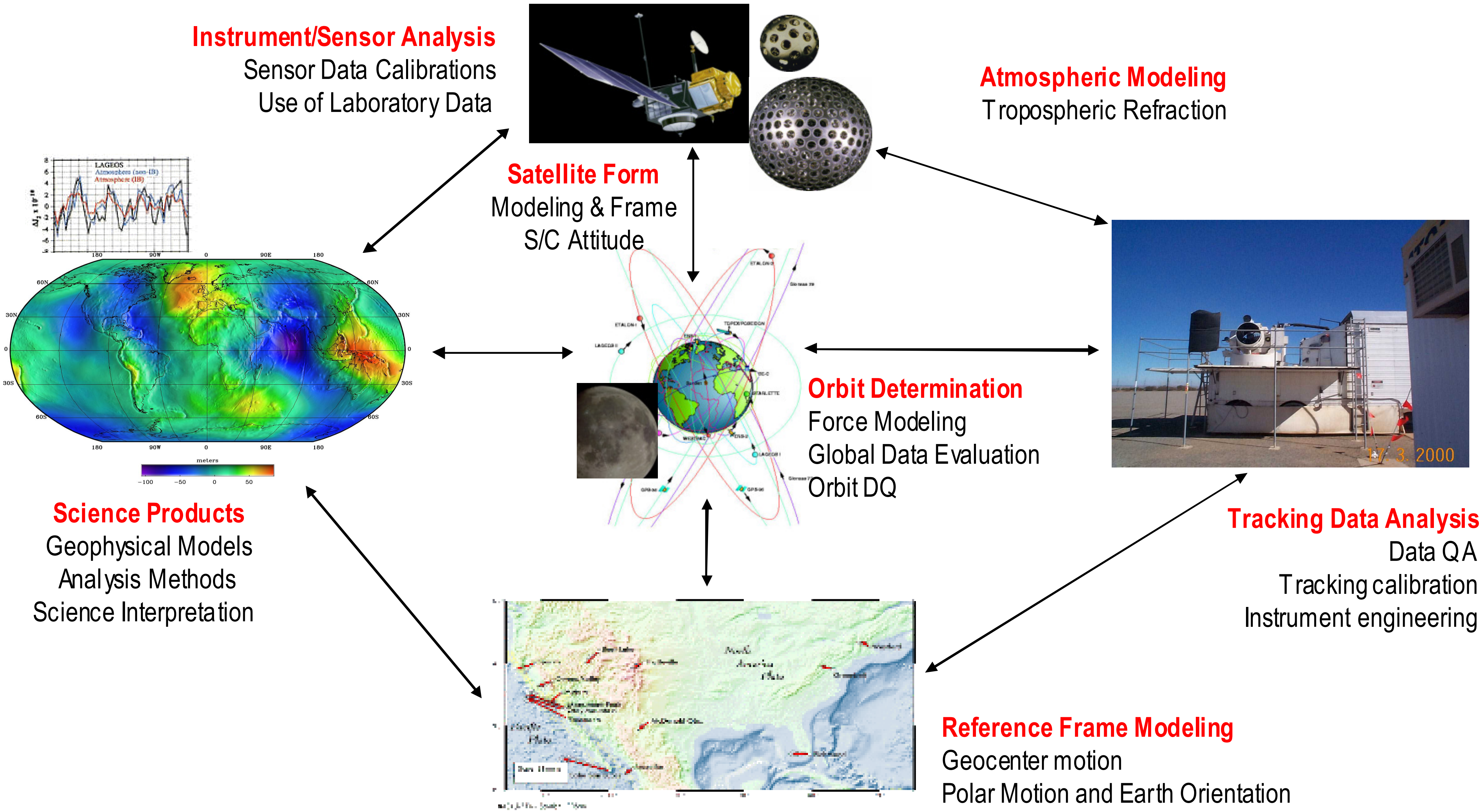
October 2006



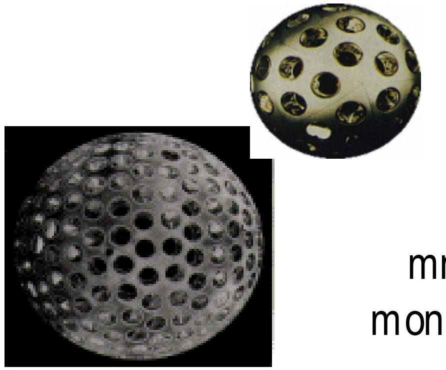




SLR INVESTIGATION LIFE-CYCLE



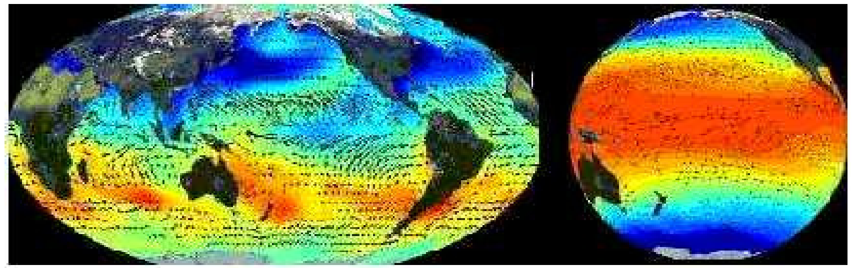
PRECISION ORBIT DETERMINATION

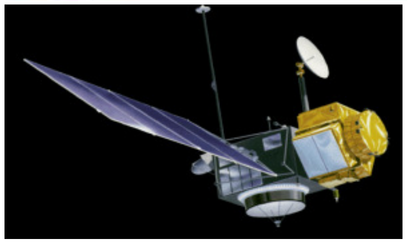


Satellite Laser Ranging
state-of-the-art precision OD
mm tracking site locations
mm/yr tectonic motion determination
monitoring time varying gravity effects

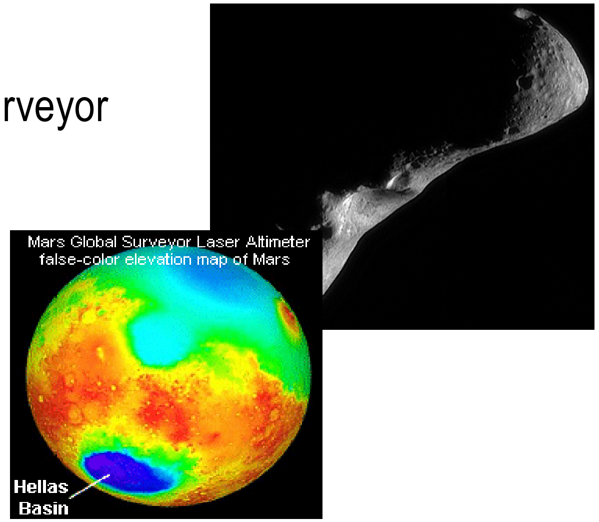
30 Years of SLR Leadership

Altimeter Mission Support
± 2 cm orbits for TOPEX and Jason





Interplanetary Applications
Precision Orbits for NEAR
2m Orbits for Mars Global Surveyor assisted with Laser Altimeter Crossovers

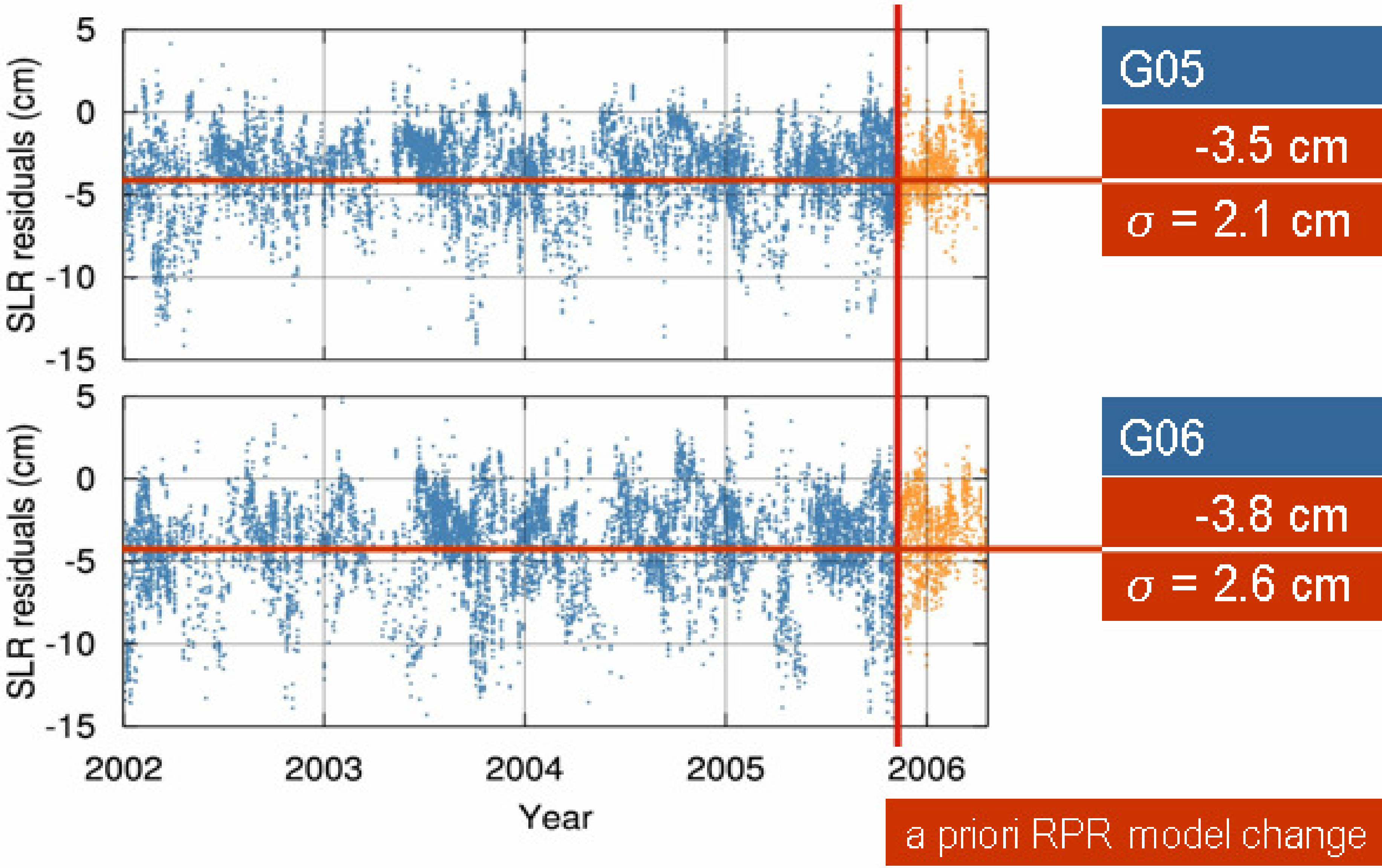


Calibrating GNSS orbits with SLR tracking data (Urschl et al)

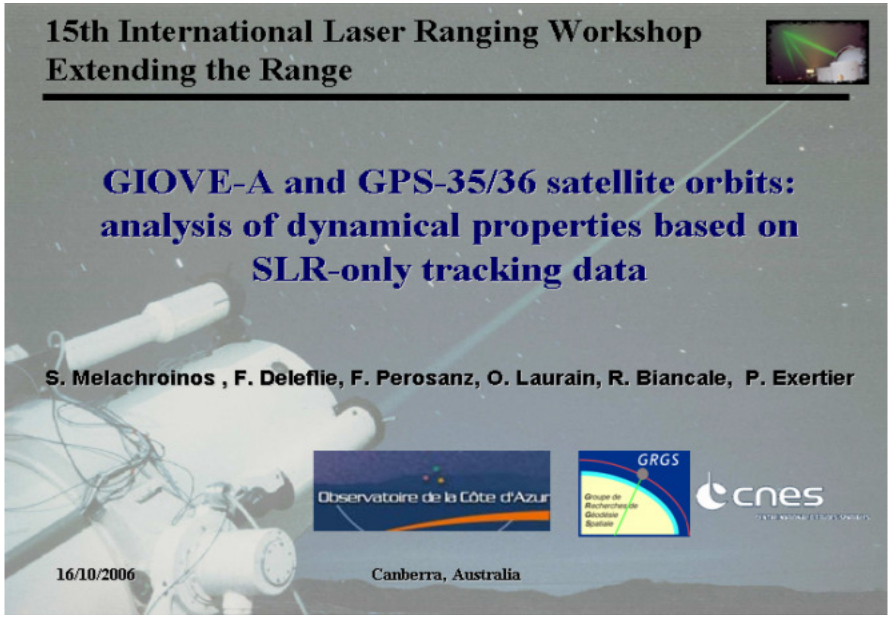
SLR range residuals

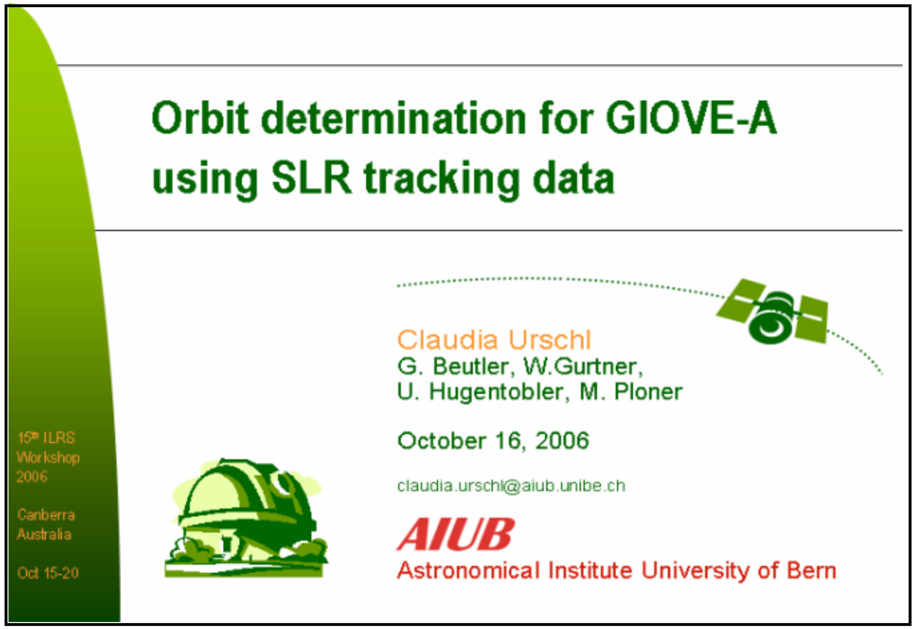
SLR observations are very useful for independent validation of microwave orbits.

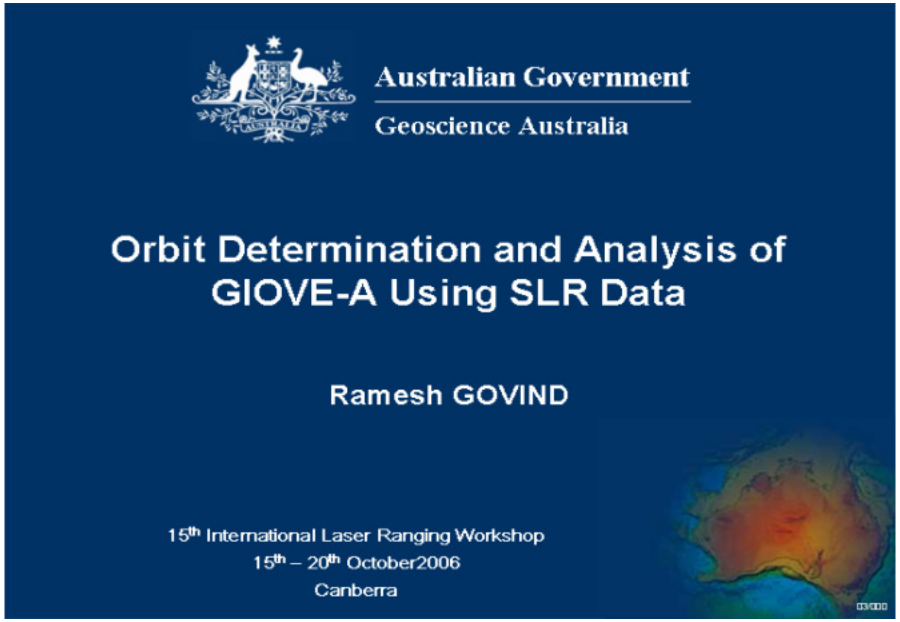
CODE final GPS orbits

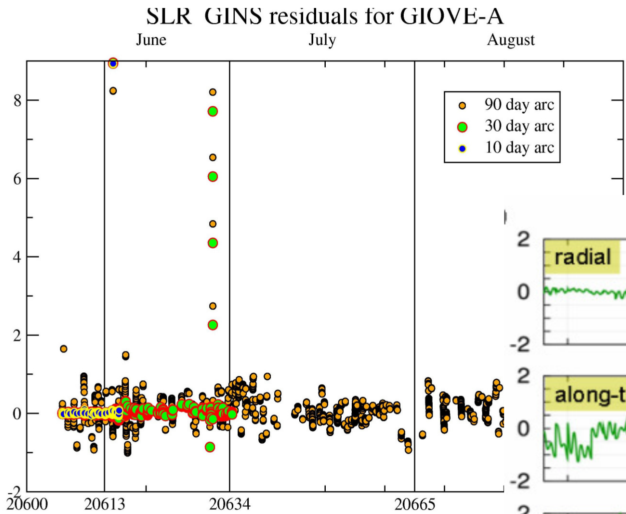


PRECISION ORBITS for GIOVE-A

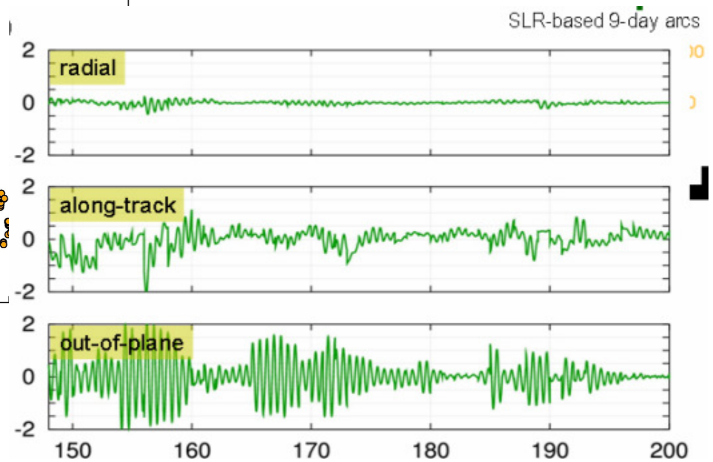






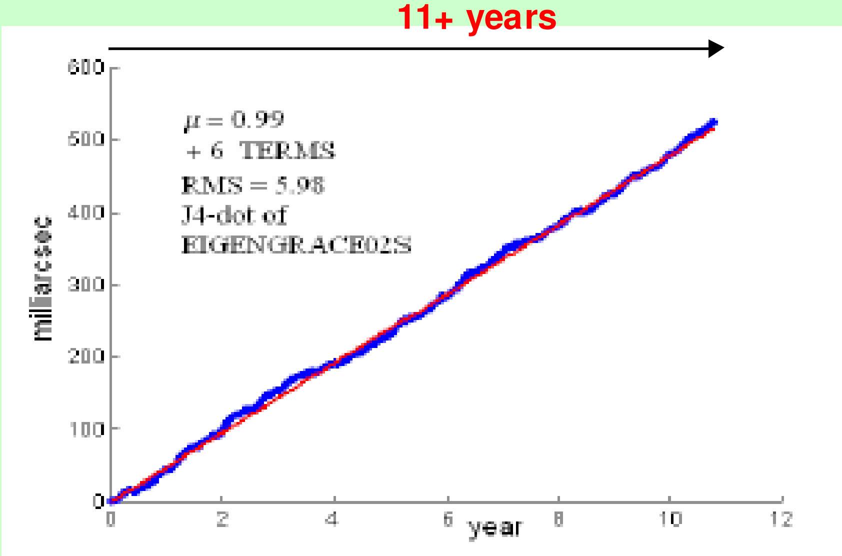


Consistency Tests to Optimize Results



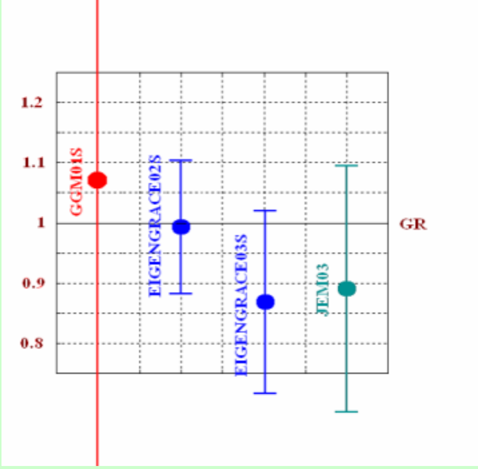
Manoeuvrers

Lageos Node Combination Residual Compared to Predicted LT Effect (Pavlis)

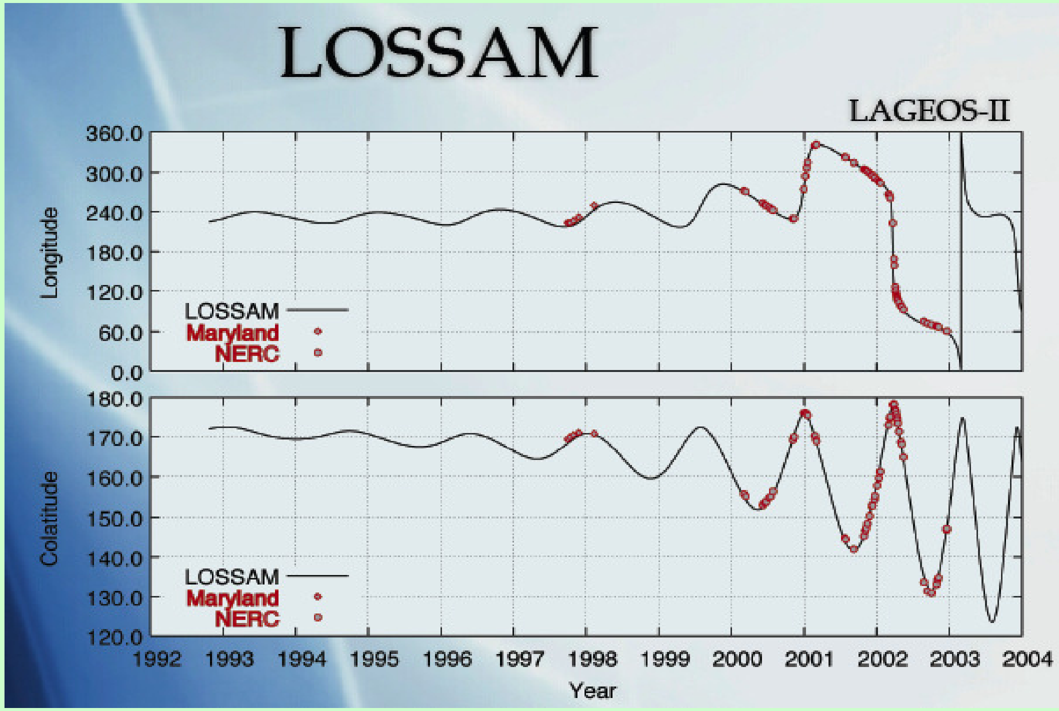


μEIGEN-GRACE02S = 0.992 ± 0.05

LLR (Murphy) = ± .001

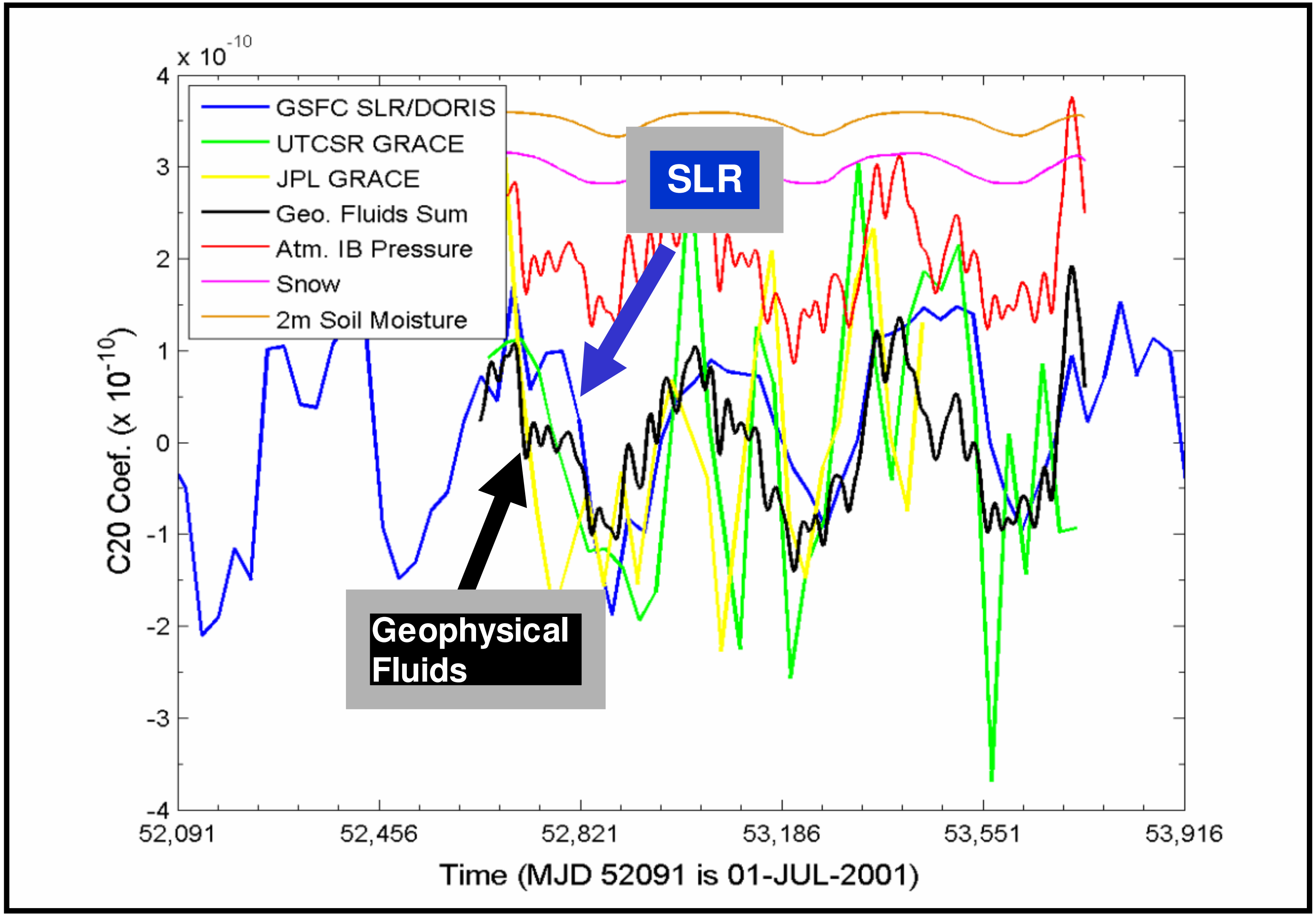


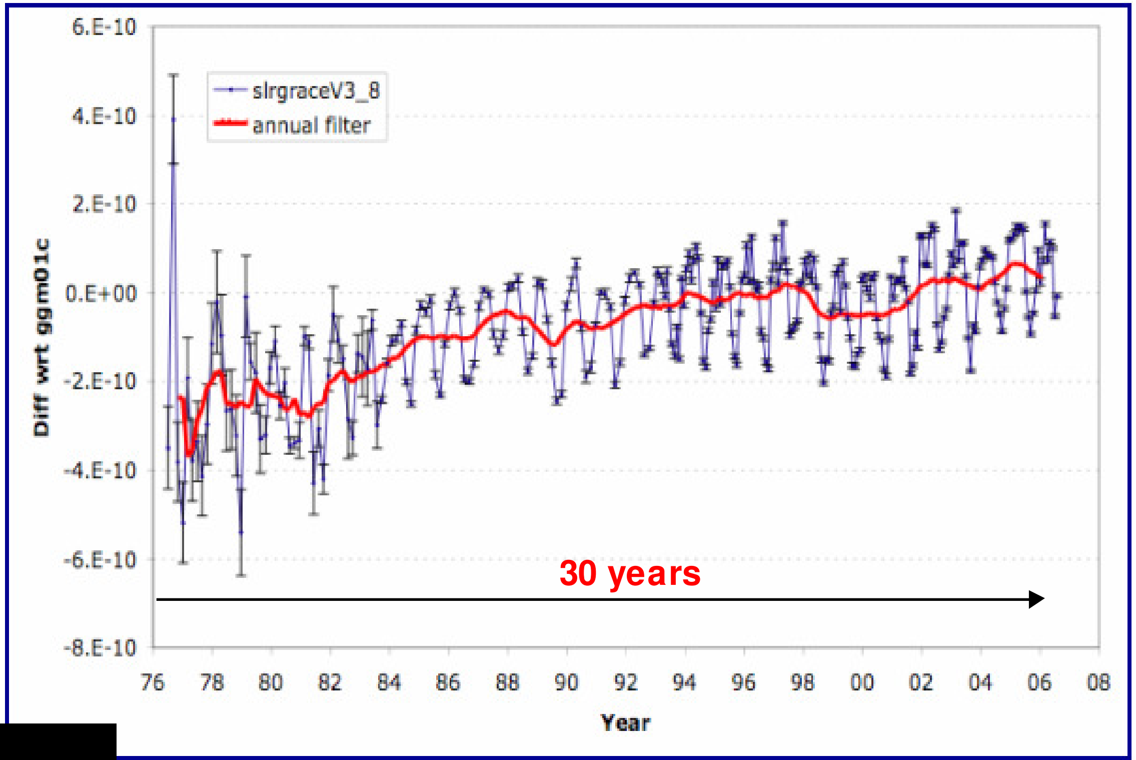
Lageos II Modeled and Observed Spin Orientation Needed for Advanced Thermal Models (Noomen); Lageos Spin Modeling (Kucharski)



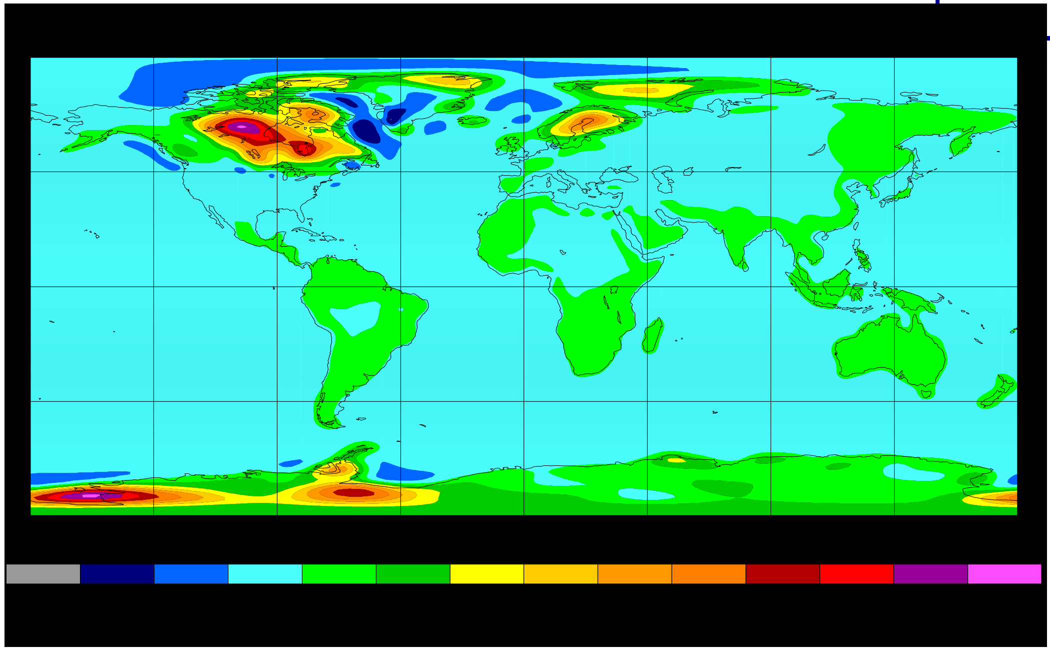
Advances in Physical Understanding

$C_{2,0}$: Comparison: SLR vs GRACE monthly (Lemoine)





Rate of Radial Displacement Predicted from PGR Model Developed from ICE-5G (Peltier)



C2,0: SLR 30 yr Evolution (Lemoine)

Post Glacial Rebound

Terrestrial Reference Frame

(Polar Motion, Earth Rotation, Geocenter, Station Motion)

SUB-CM EARTH MEASUREMENTS

mm-level Geodesy requires understanding of the reference frame and its distortions to acute levels of precision.

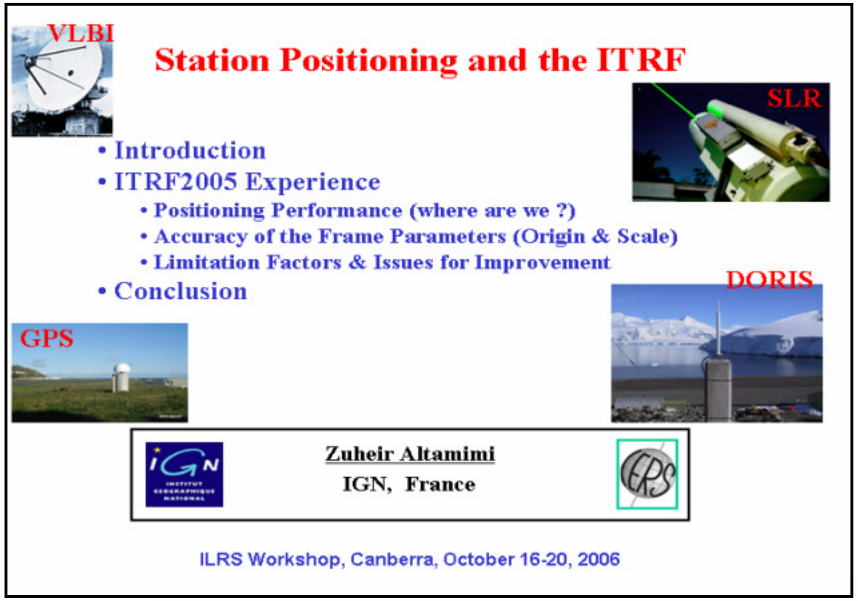
.

Geospatial component

Lambeck:

- AuScope

- Core research infrastructure to deliver a geodetic positioning capability of 1cm accuracy in real time and 1mm accuracy in post-event processing across the Australian region.
- To provide a capability for crustal deformation and environmental monitoring that will underpin the GeoTransect program and to provide a coherent and national framework for geospatial applications.

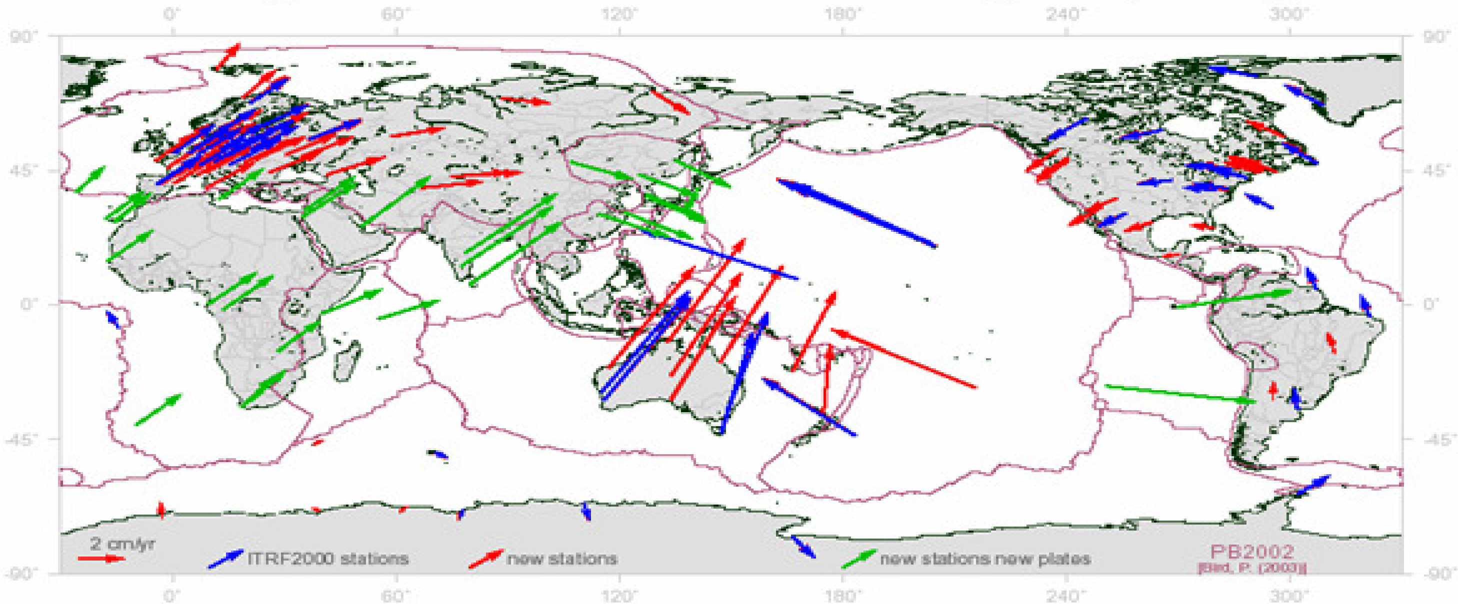


International Terrestrial Reference Frame

Example of selected sites for plate angular velocities estimation

- Pacific
- Africa
- Amur
- Antarctica
- Arabia
- Australia
- Caribbean
- Eurasia
- India
- North America
- Nazca
- Okhotsk
- South America
- Somalia
- Yangtze

Using PB 2002 Plate boundaries (Bird, 2003)



Australian Government
Geoscience Australia

Determination of the Temporal Variations of the Earth's Centre of Mass from Multi-Year SLR Data

Ramesh GOVIND

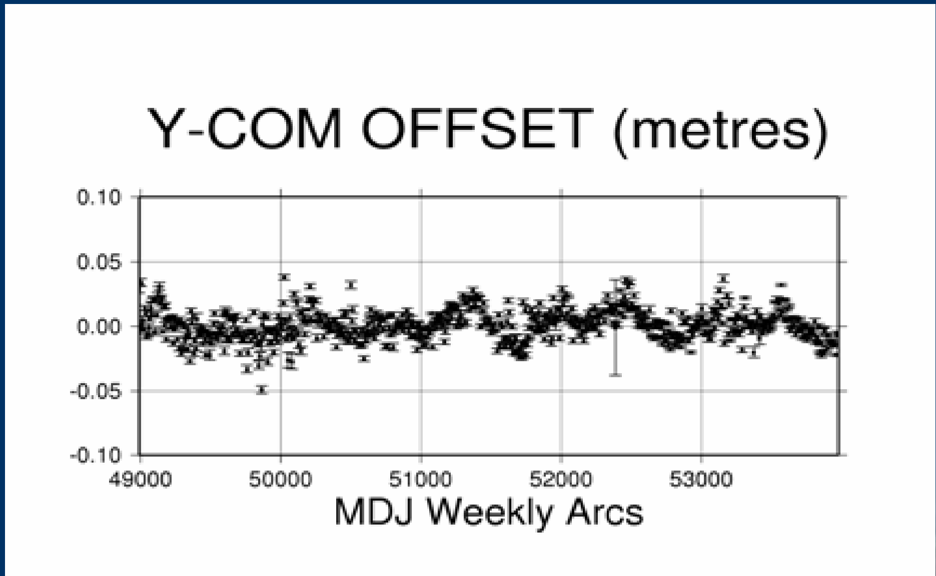
15th International Laser Ranging Workshop
15th – 20th October2006
Canberra

Geocenter Monitoring Using SLR (Govind)

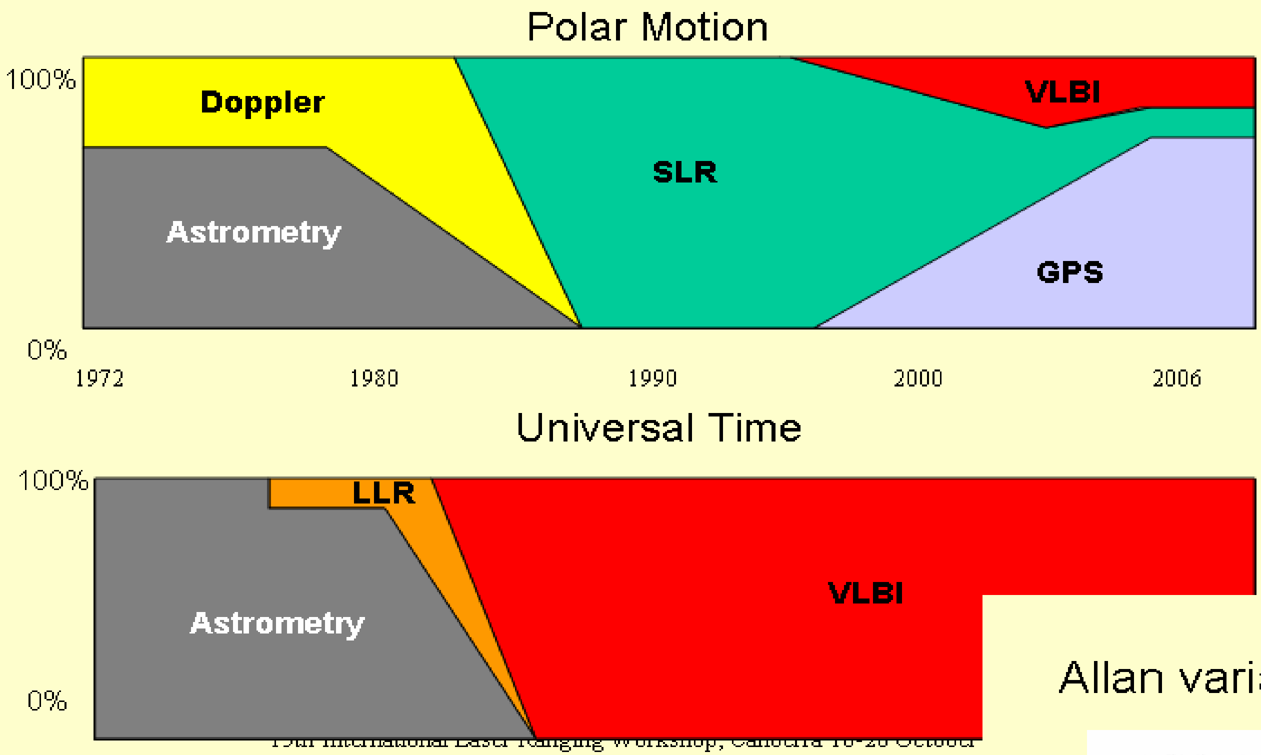
Lageos: COM Results

Dominant Periods

- *≈ 1200 days (39 months) – 2 cm*
- *≈ 900 days (30 months) – 3 cm*
- *≈ 18 months – 3 cm*

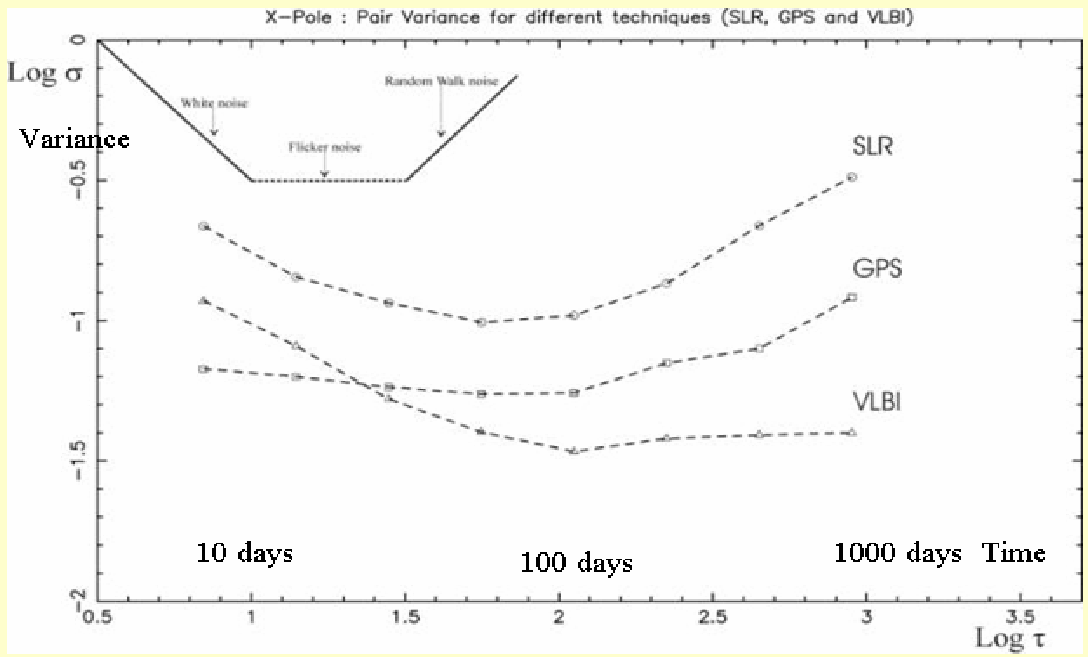


Contributions of techniques to EOP combined solutions

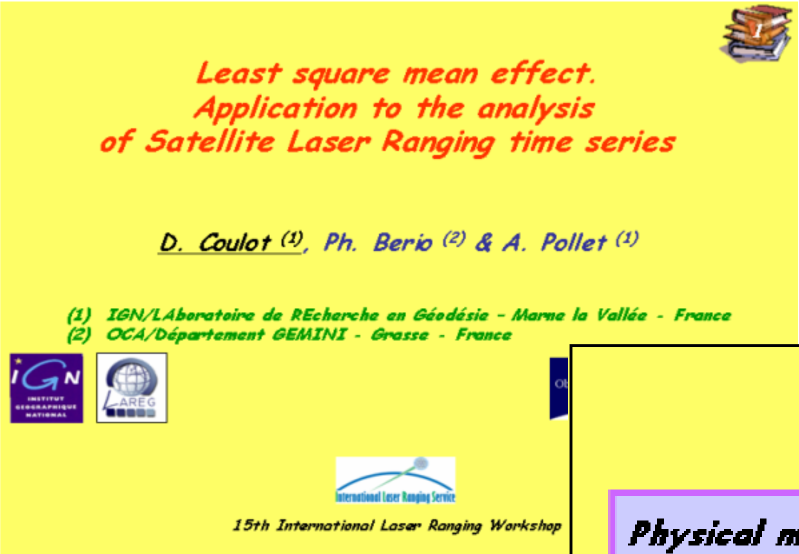


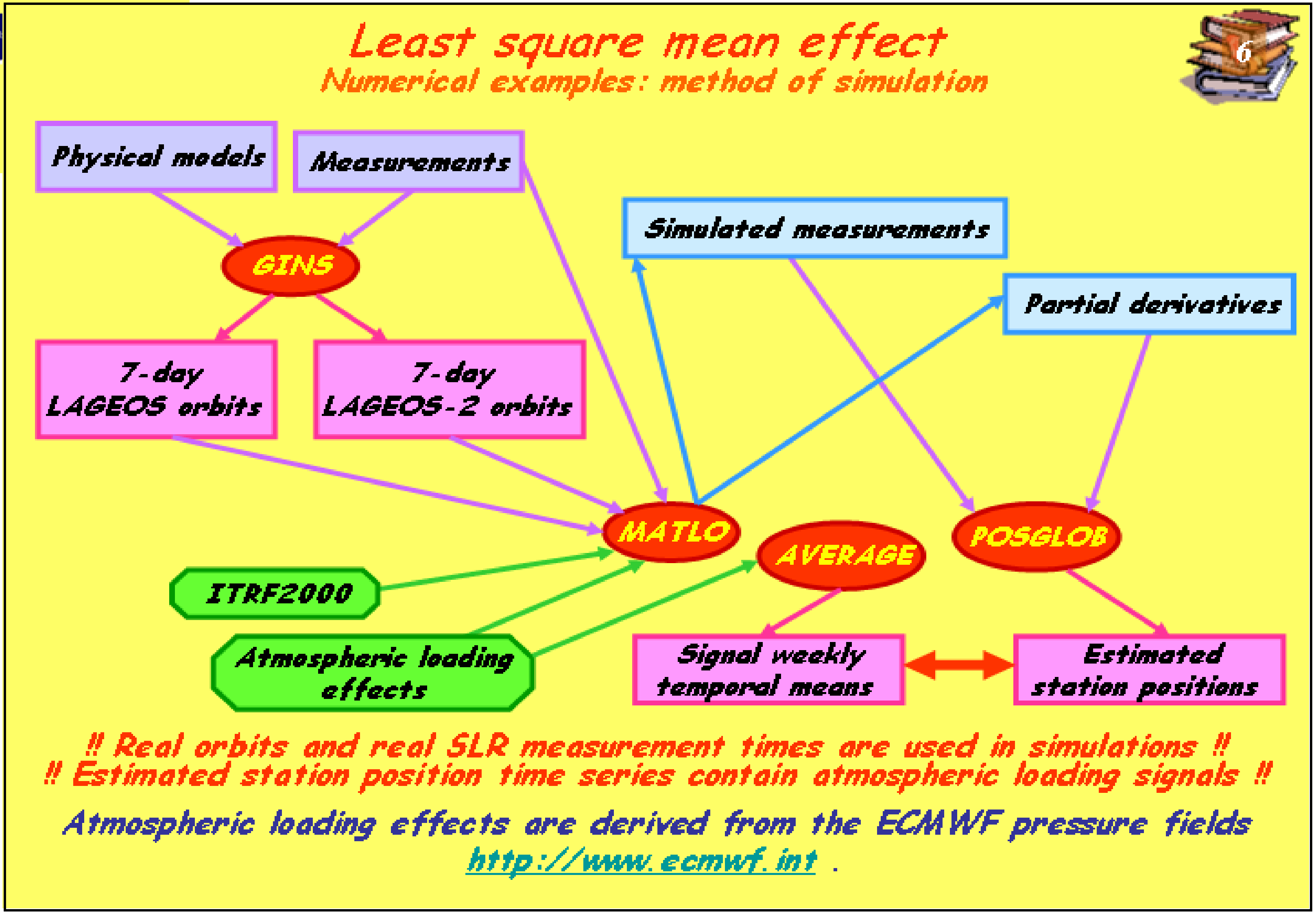
Optimal Combination of Techniques (Gambis)

Allan variance analysis for SLR, GPS and VLBI



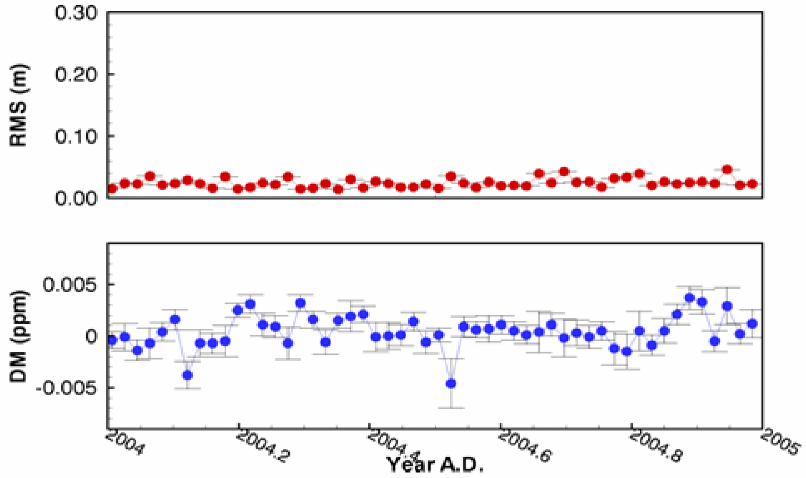
Improved Treatment of Time Varying Signals (Coulot)





DGFI

7-Param Transformation EPOS solution vs. ITRF2000: Disclosures (RMS) vs. Scale (DM)



AFTER station disclosure Screening

-> Some peaks in scale removed

Scale between SLR and VLBI

	Δ Scale offset [ppb]	Δ Scale drift [ppb/yr]
SLR - VLBI	0.40 ± 0.42	0.04 ± 0.10
SLR – VLBI *	**0.26 ± 0.41**	**0.03 ± 0.09**

*** : Discontinuity for GPS station Maui introduced**

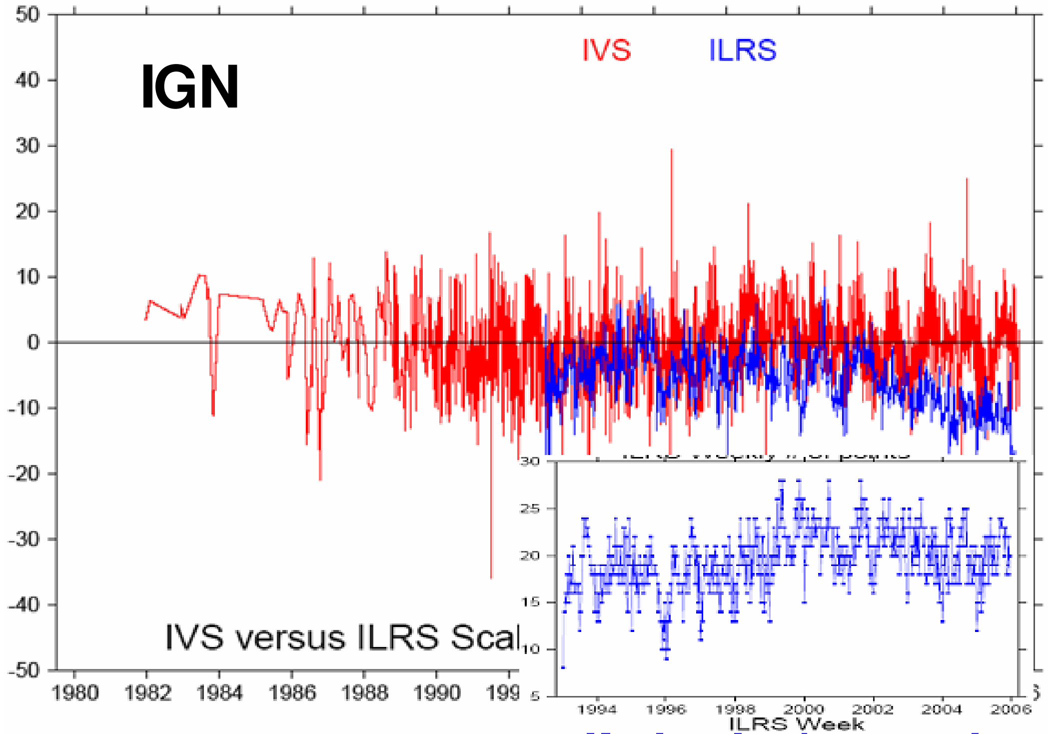
Some remarks:

- The scale difference between SLR and VLBI is obtained „indirectly“ via similarity transformations w.r.t. the GPS network.
- The estimated scale differences are very small and not significant.
- Much effort was made to select the „best“ co-location sites w.r.t. quality and spatial distribution.

SLR vs VLBI Scale: 1.7ppb???

?

VLBI vs SLR Scale wrt ITRF2005



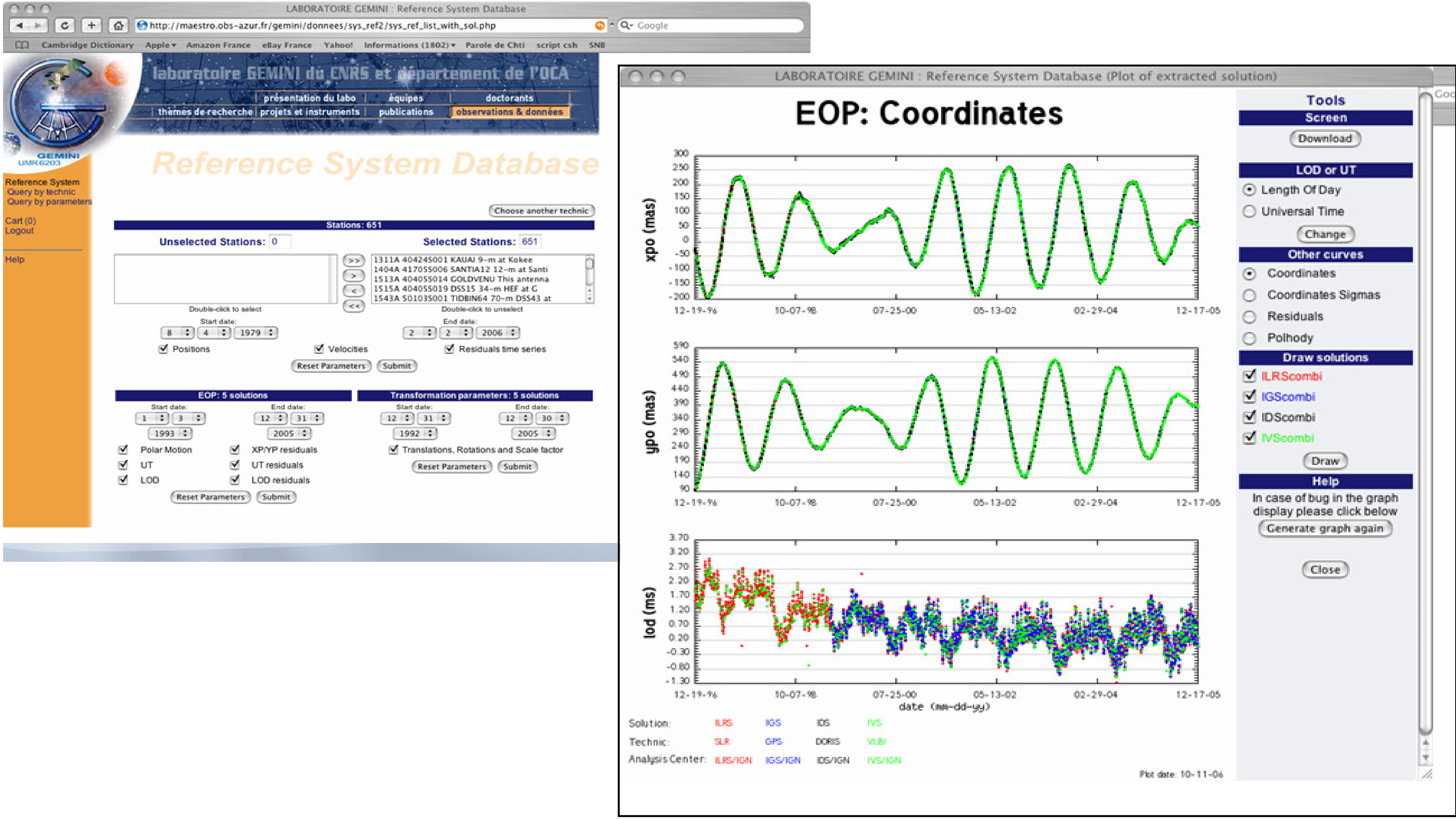
Number of stations per week

Conclusions

- **Origin:**
  - **Significant drift / ITRF2000 in TZ : 1.8 mm/y**
  - **Consider Impact on ITRF2005 velocity field**

    (ITRF2005 velocities are 1.8 mm/yr larger than ITRF2000)
- **Scale:**
  - **~ 1 ppb bias btw solutions from VLBI and SLR**
- **NNR Condition: Still at the level of 2 mm/yr**
- **Still too many issues to improve …**

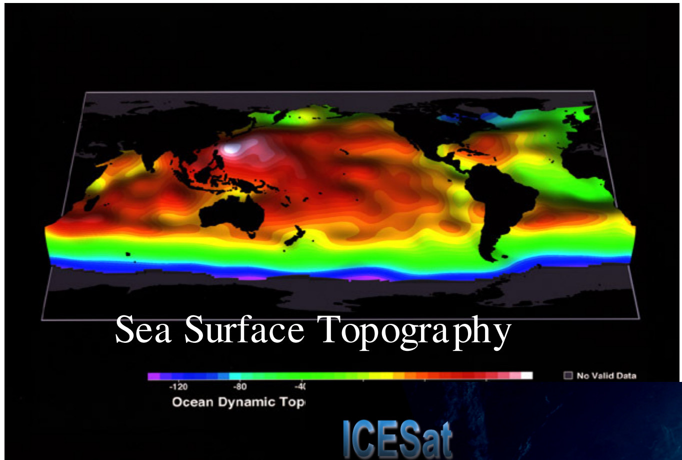
WWW Based Service to Compare Geodetic Time Series (Deleflie)

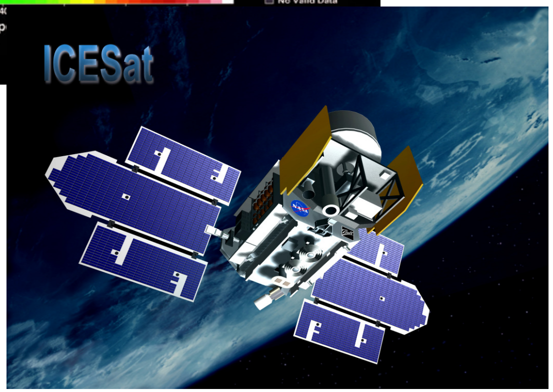


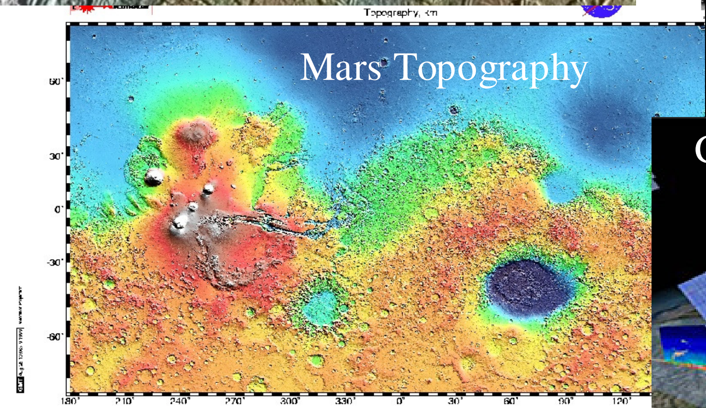
LASER SATELLITE ALTIMETRY

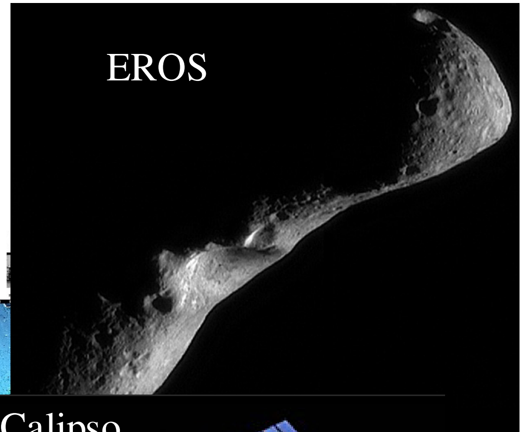
- Laser Altimetry
  - Earth/planetary topography
  - Biospheric monitoring
  - Interplanetary applications

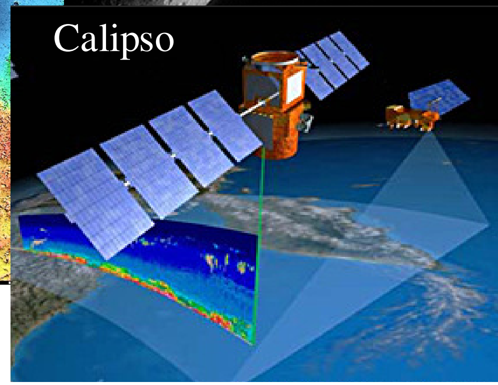
- *Mars Global Surveyor*
- *Near Earth Asteroid Rendezvous .*
- *ICESat*
- *Shuttle Laser Altimeter*
- *Lunar Reconnaissance Orbiter*
- *Mercury Messenger*



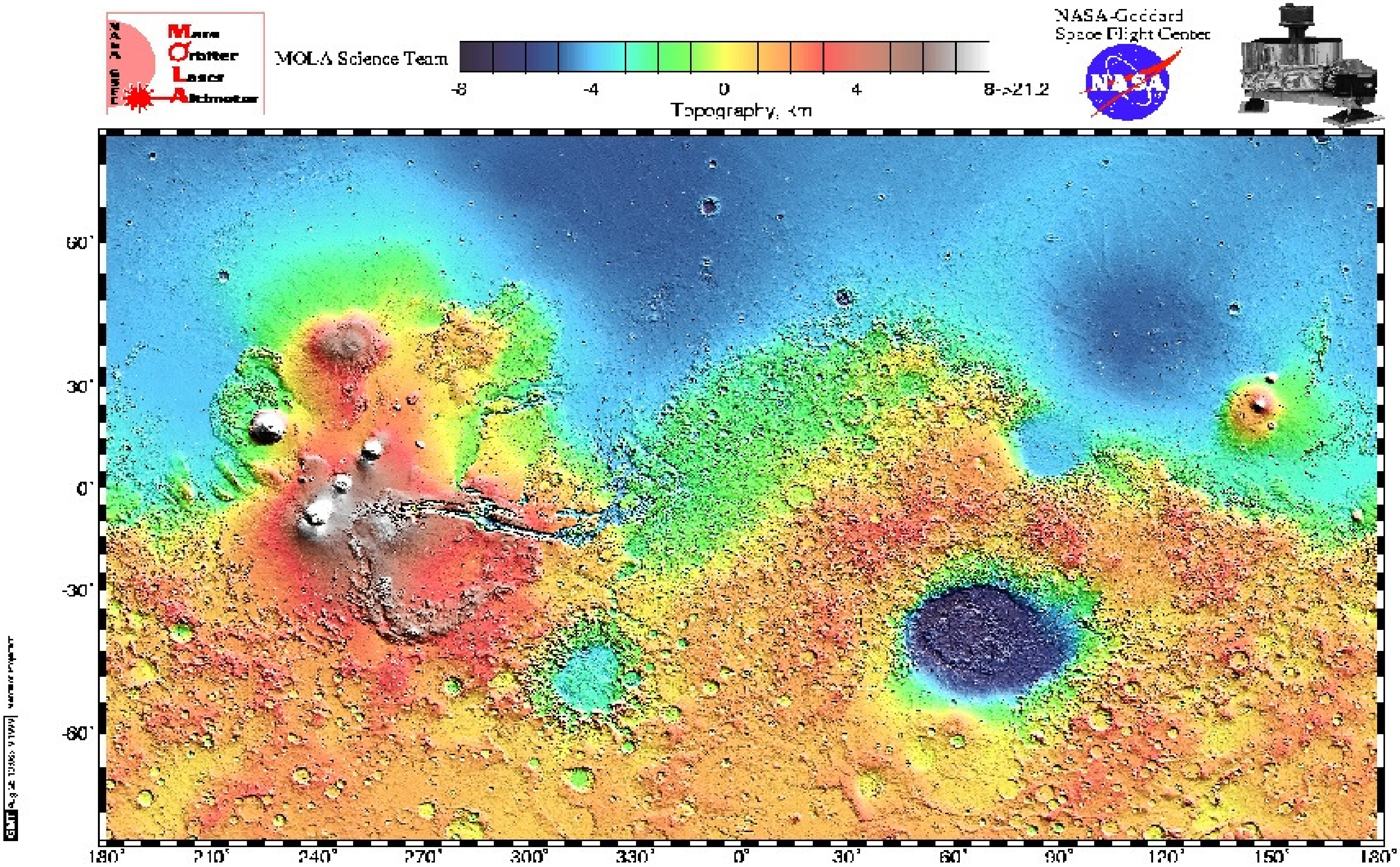






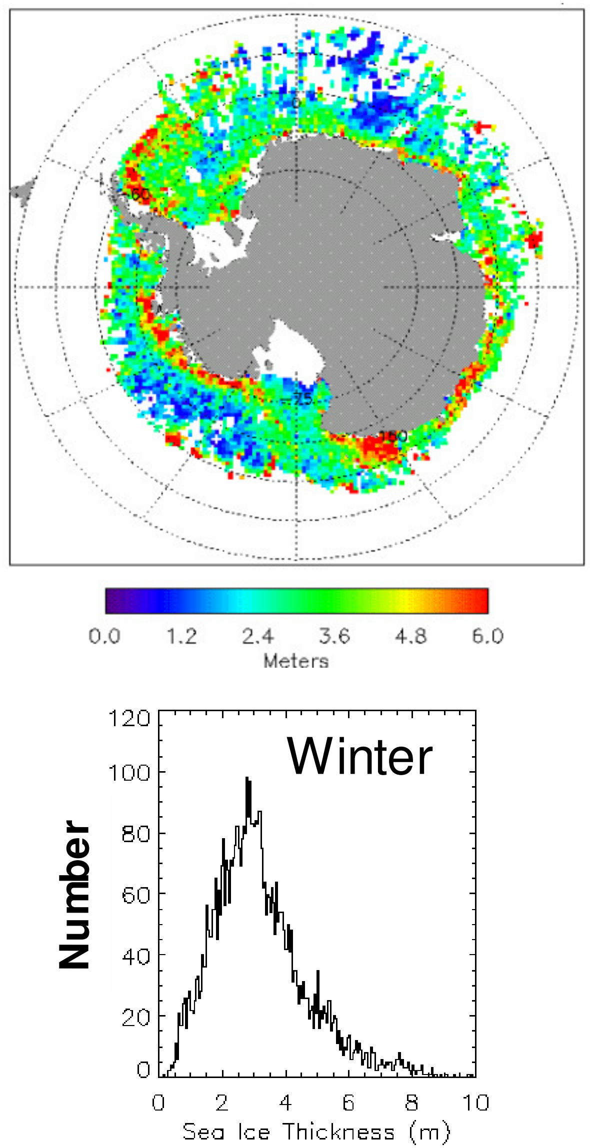


Mars Surface Topography from MGS/MOLA

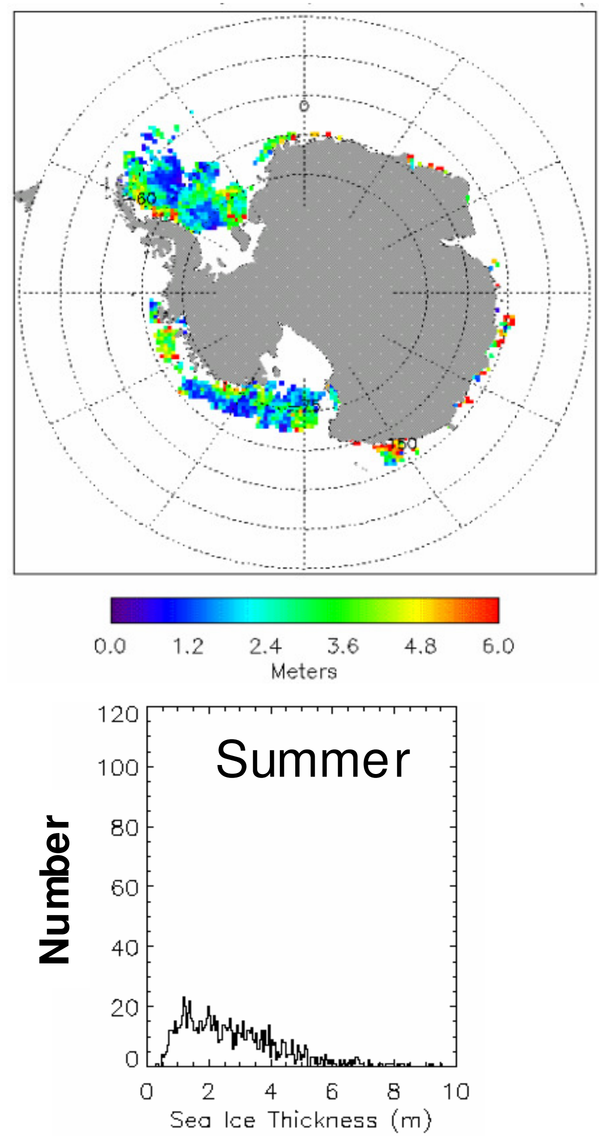


First Sea Ice Thickness Maps From ICESat

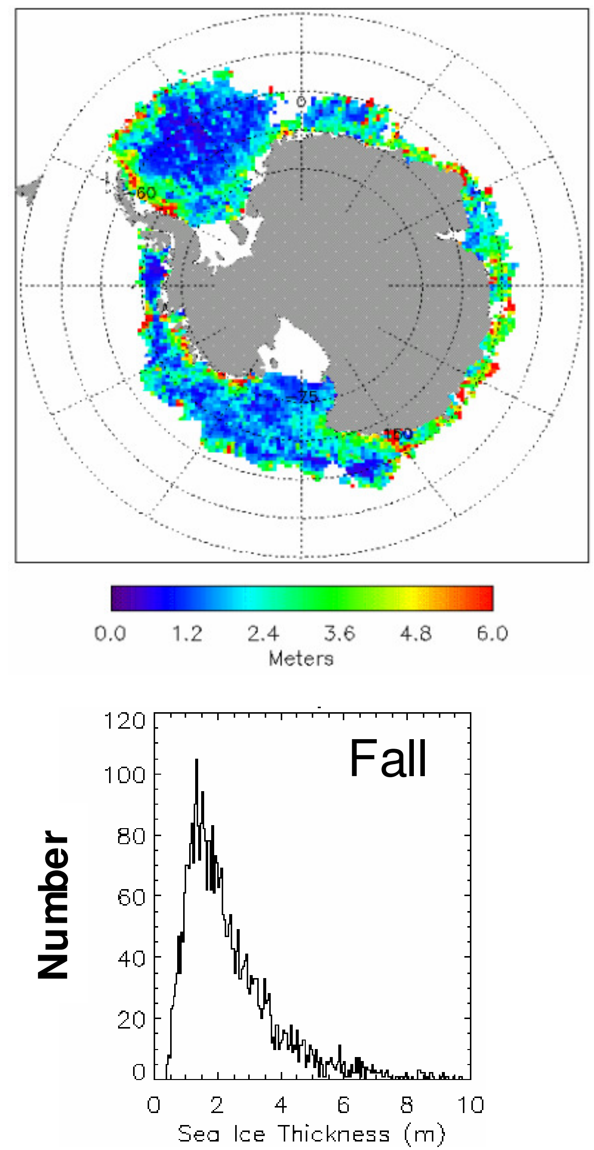
Sea Ice Thickness
Oct 4 – Nov 18, 03

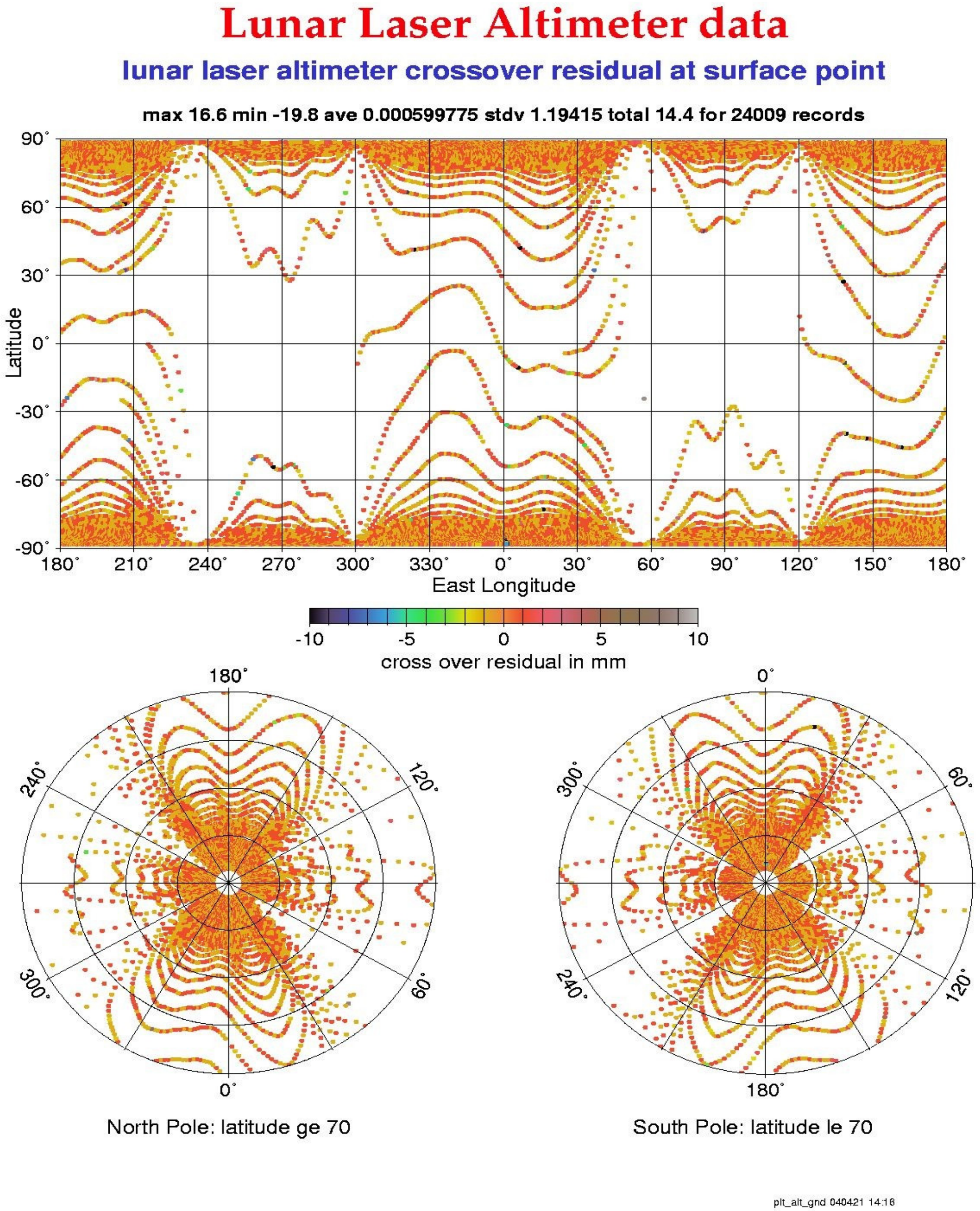


Sea Ice Thickness
Feb 18 – Mar 21, 04



Sea Ice Thickness
May 15 – Jun 24, 04





SIMULATIONS FOR LRO

- **Simulations of a Lunar Orbiter mission flying an altimeter were undertaken in support of GSFC's proposal for this round of Discovery Missions. These simulations assessed the efficacy of using altimeter cross over data to improve satellite positioning and gravity recovery on the far side of the moon**

Summary

- Observations Acquired by SLR, LLR, and Laser Altimetry are Major and Unique Science Resources
- Major Advancements in Modeling
  - Gravity field accuracy
  - Astrodynamic forces
  - Thermal characterization of satellite components
  - SLR data analysis techniques and correction algorithms
- Limitations
  - Best SLR precision $\underset{\sim}{}$ 1-2 mm; Best orbit reductions $\underset{\sim}{}$ 1-2 cm
  - Significant signal remains to be understood and exploited
  - Terrestrial Reference Frame:
    - Results are currently analysis center specific and rely on processing approaches
    - Significant and pressing need for resolution