JPL Welcome

Jet Propulsion Laboratory
California Institute of Technology

to the

International GNSS Service
20th Anniversary Workshop

June 23, 2014

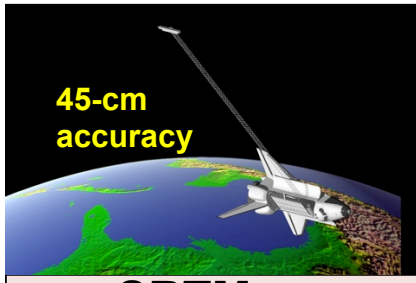
Lt. Gen Larry James, Deputy Director
NASA Jet Propulsion Laboratory
California Institute of Technology


NOT A
THRU ROAD
YOUR GPS
IS WRONG!

JPL Precision Tracking in Space

Over 160 receiver-years of successful operation

Jet Propulsion Laboratory
California Institute of Technology

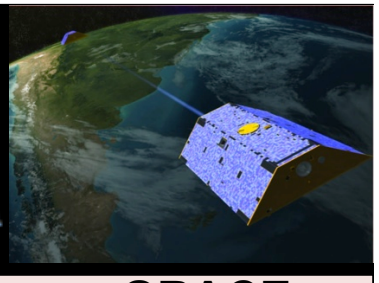


SRTM
Feb 2000

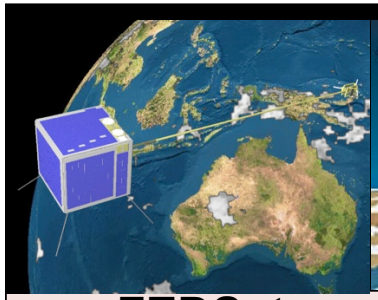
CHAMP
Jul 2000

SAC-C
Nov 2000

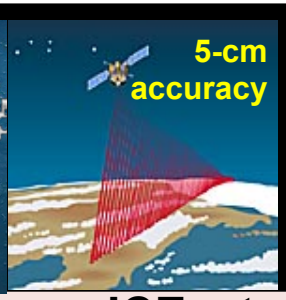
JASON-1
Dec 2001



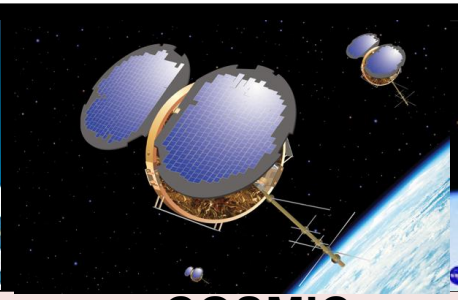
GRACE
Mar 2002



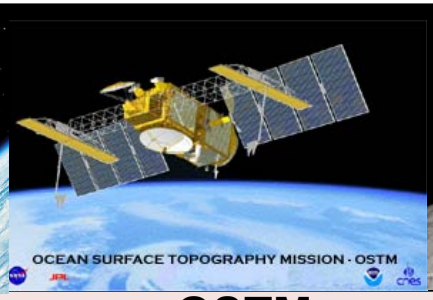
FEDSat
Dec 2002



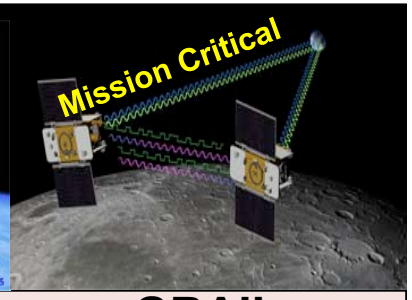
ICEsat
Jan 2003



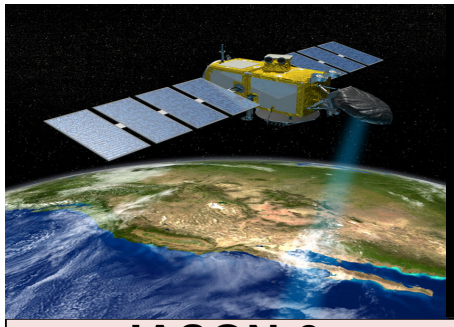
COSMIC
Apr 2006



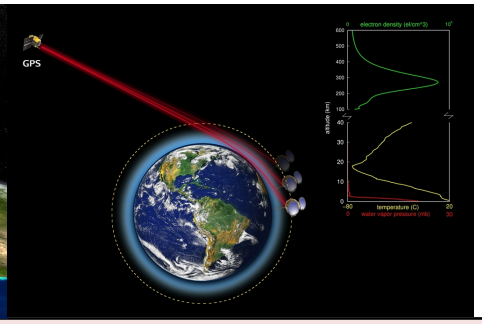
OSTM
Jun 2008



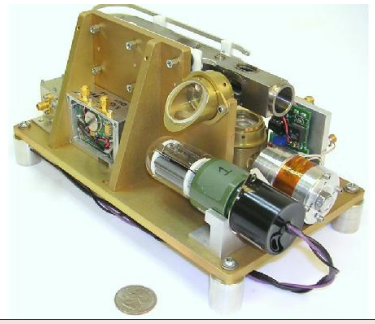
GRAIL
Sept 2011



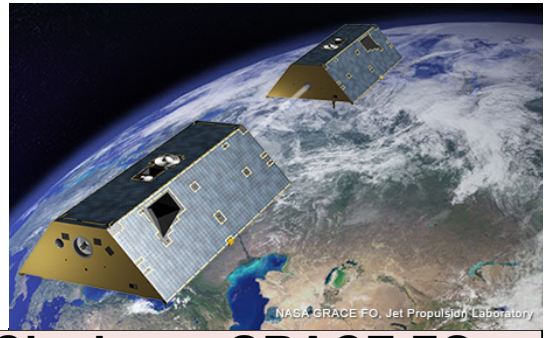
JASON-3
2015



COSMIC-2
2016



Deep Space Atomic Clock
2016



GRACE FO
2017

GPS/GNSS and GPS-Like Remote Sensing

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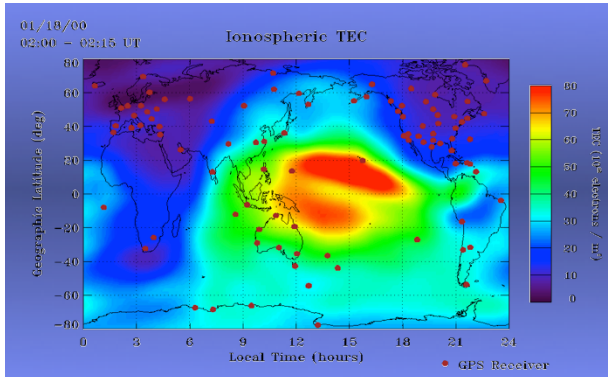
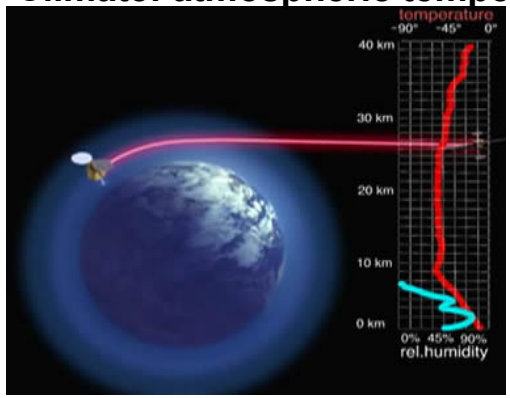
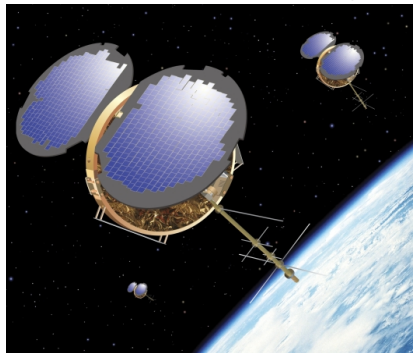
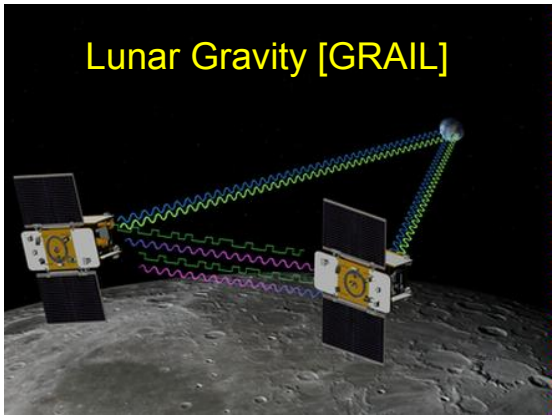
Space Weather

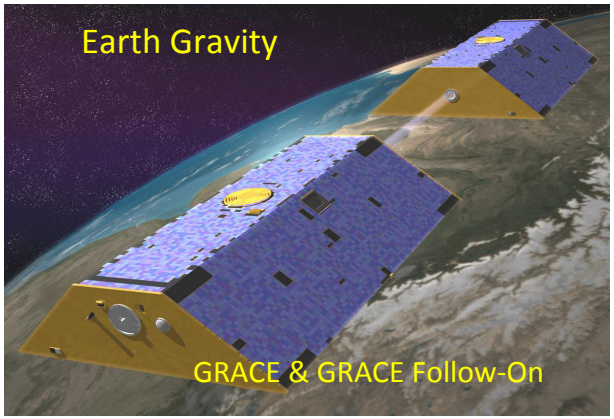


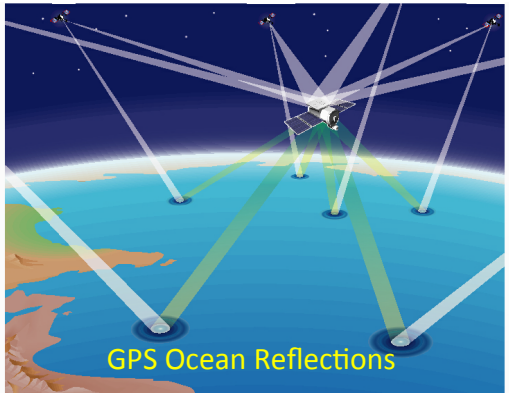
Climate: atmospheric temperature, pressure, humidity profiles

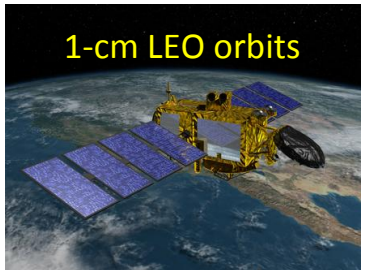


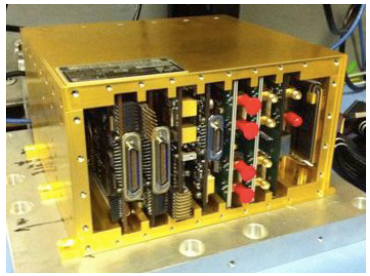












High precision GPS Flight Receivers

Next Gen GPS Systems (with USAF)

GNSS Radio Occultation for Neutral Atmosphere and Ionosphere

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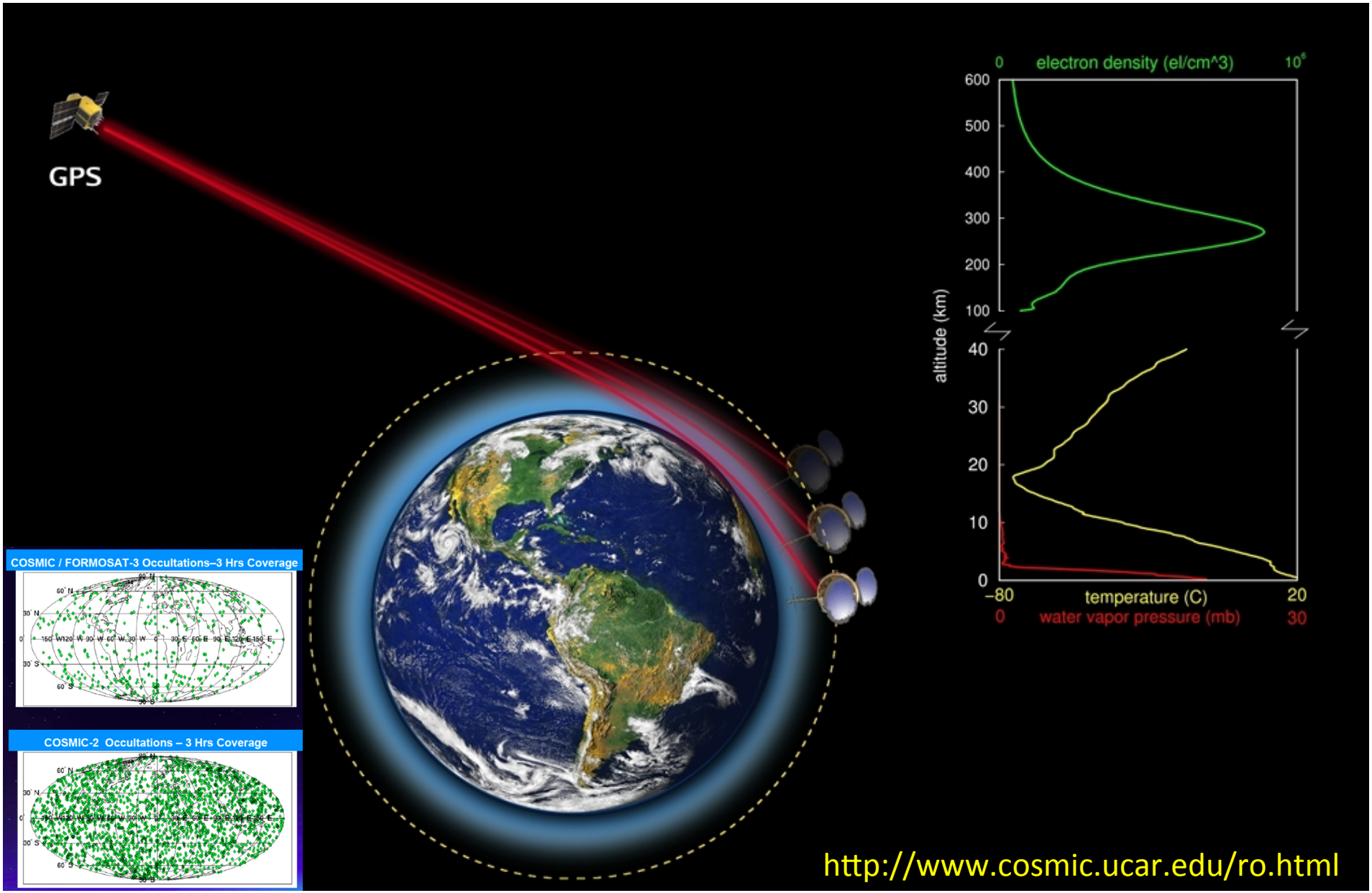
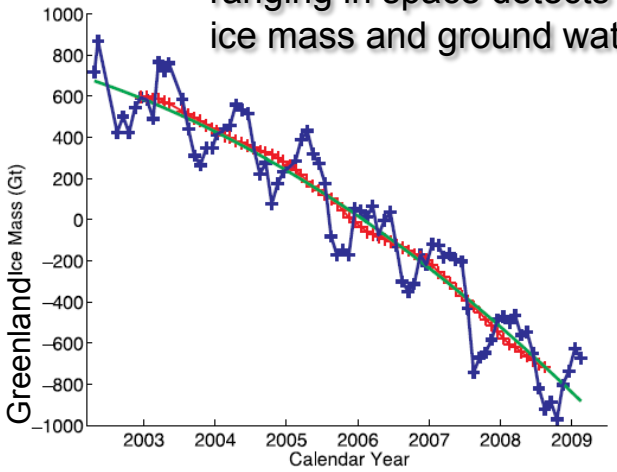


GRACE Does Amazing Science

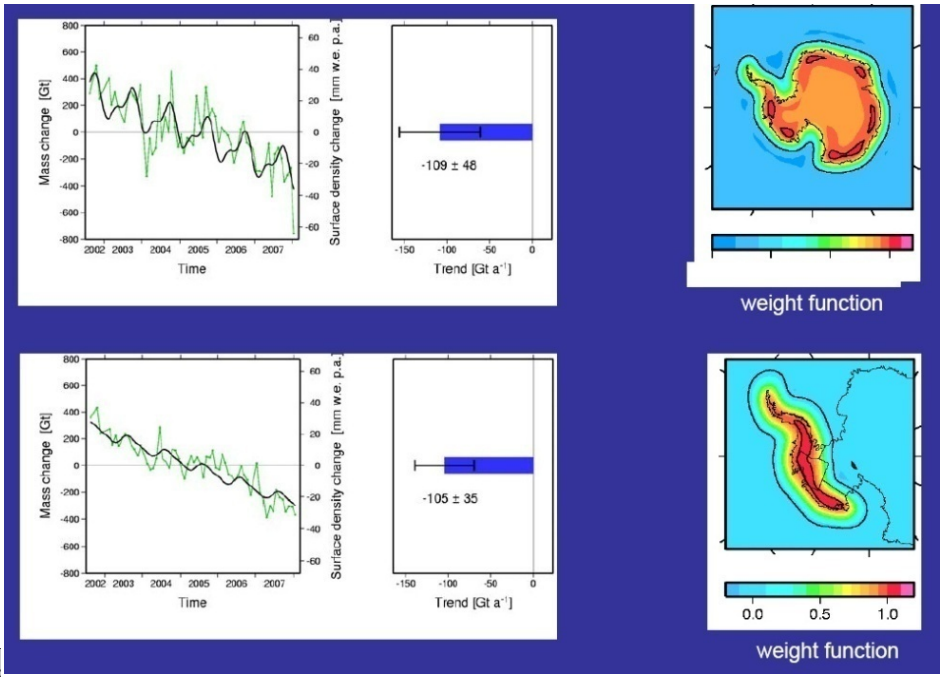
(and GRACE Follow-On will continue to do so in a spirit of international cooperation)

GPS + two-spacecraft micron-level ranging in space detects changes in ice mass and ground water on Earth

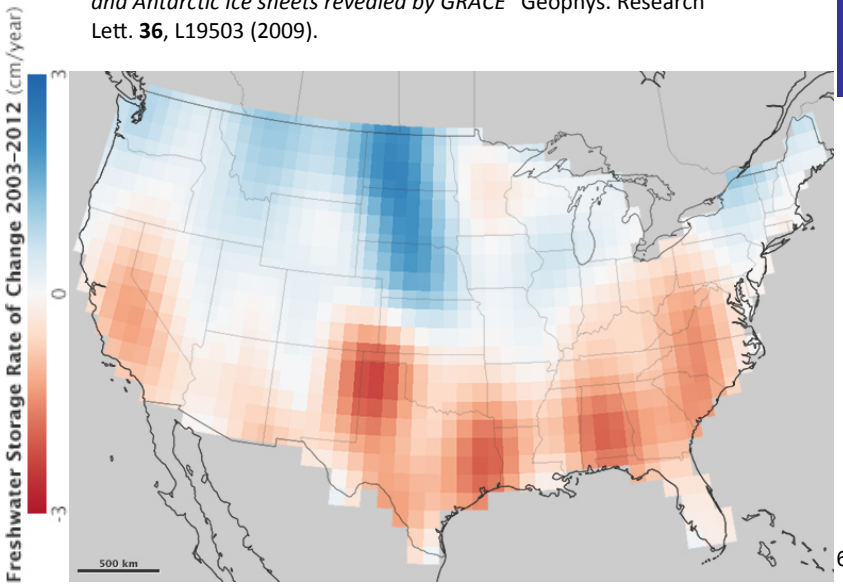


Velicogna, *"Increasing rates of ice mass loss from the Greenland and Antarctic ice sheets revealed by GRACE"* Geophys. Research Lett. **36**, L19503 (2009).

Antarctica



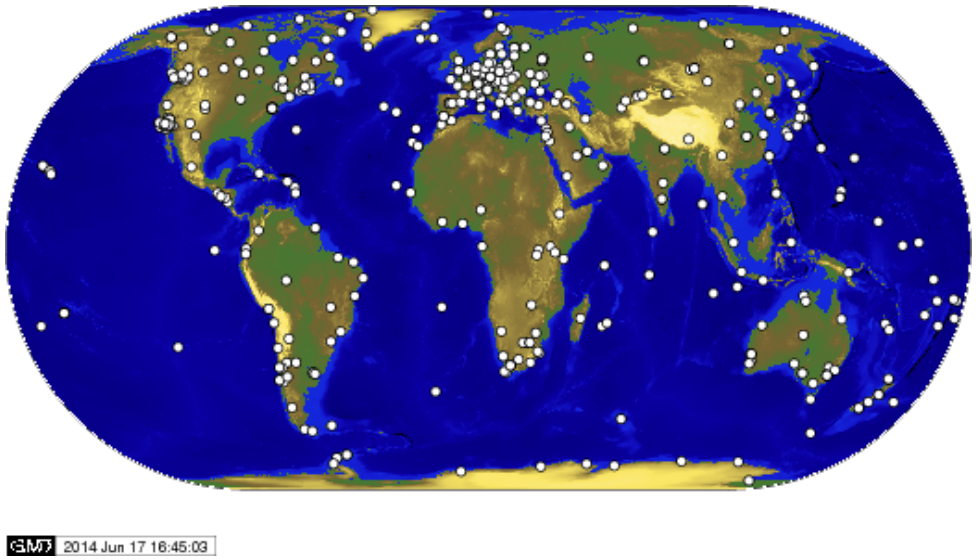
Horwath and Dietrich, Geophys.J.Int 2009



Ground water in the US (2003 – 2012)

Famiglietti, J.S. and Rodell, M. (2013, June 14) Water in the balance. Science.

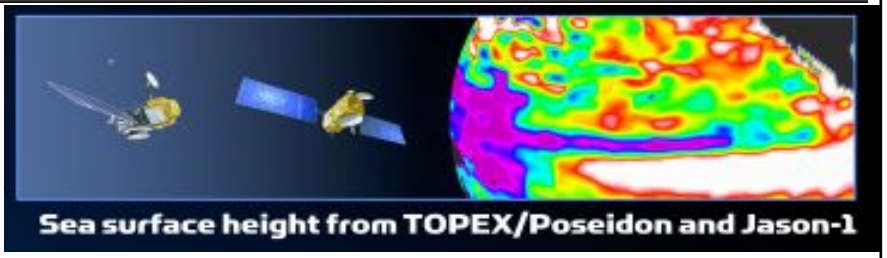
Amazing Science from Space Requires a Ground Network



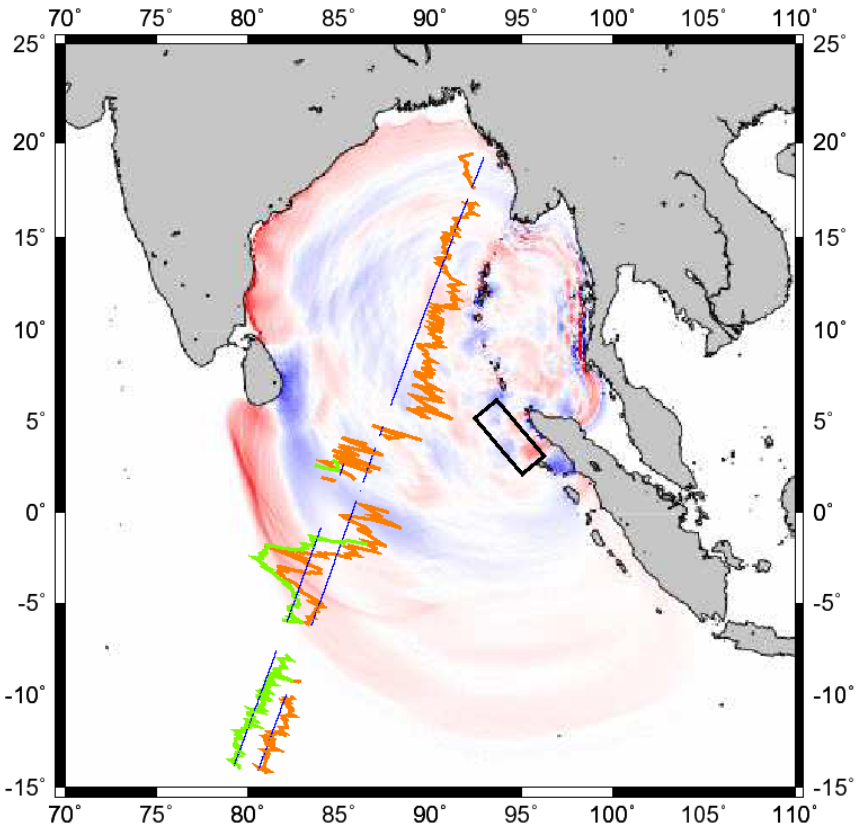
- **Geodetic and science measurements from Earth orbit with GNSS flight instruments require the highest quality GNSS ground data, which are combined with the space flight data to form the science products**
- **This holds true for Topex/Poseidon, CHAMP, SAC-C, SRTM, Jason-1, Jason-2, Jason-3, GRACE, GRACE Follow-On, COSMIC-I, COSMIC-II and other space GPS/GNSS science missions**
- **The IGS is a model of international cooperation and collaborative science and without it, the "amazing science" that has characterized the past 25 years of space geodesy would never have been possible**

"Seeing" a Tsunami with Radar Altimeters: Need to be in the Right Place at Just the Right Time

National Aeronautics and Space Administration
Jet Propulsion Laboratory
California Institute of Technology



- **JPL GPS flight receivers**
- **Orbit determination for Jason and Topex/Poseidon**
  - Near-real-time, daily, final
  - Sub-cm RMS radial accuracy for Jason
- **2004 Tsunami was detected (but not in time to warn everyone)** in Jason (orange) and Topex (green) ocean height measurements 15 minutes after the 2004 Sumatra earthquake superimposed on a model of the tsunami (shades of red and blue)
- Topex/Poseidon and Jason could "see" the tsunami as it raced across the ocean

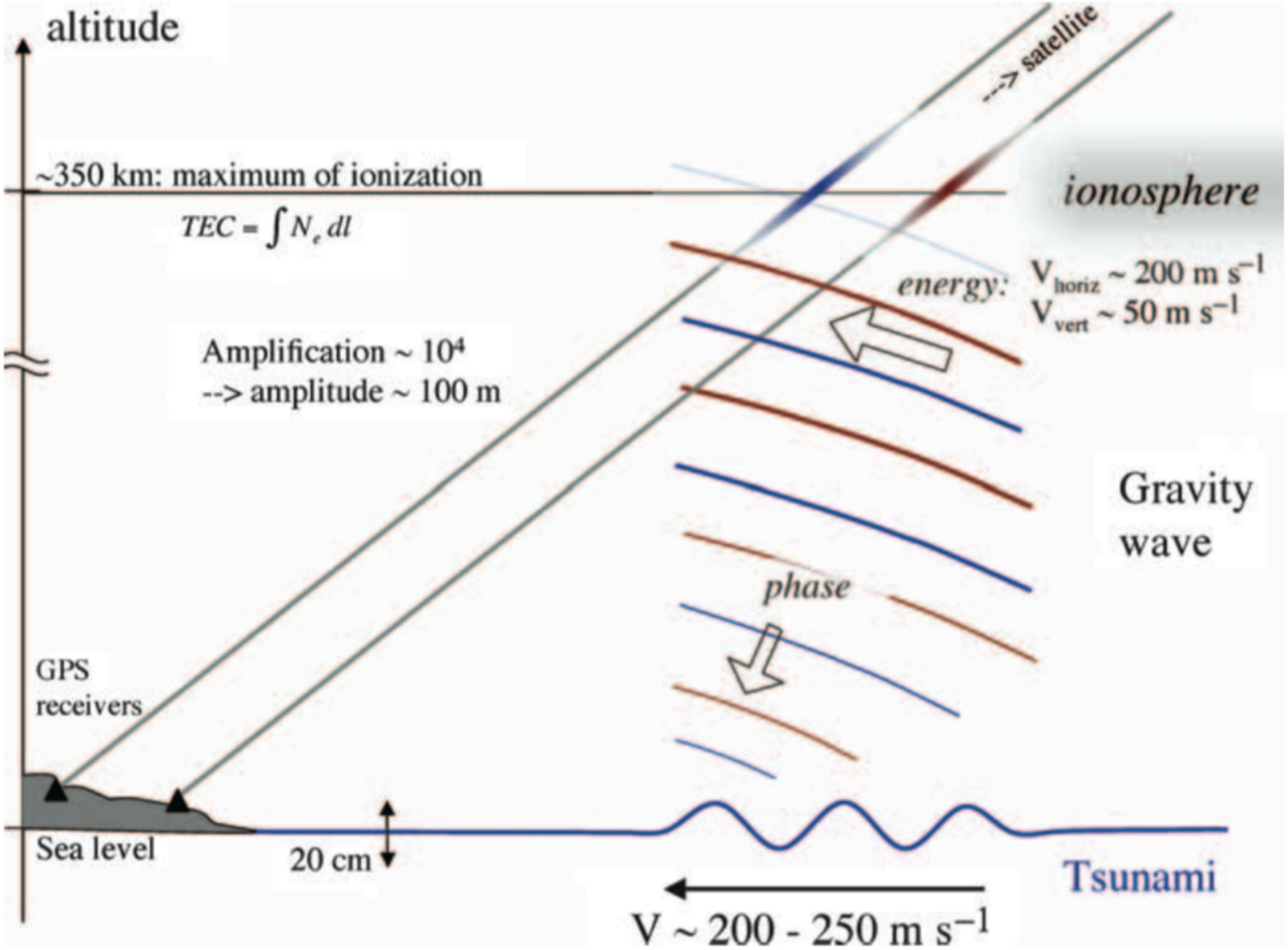


Tohoku Tsunami: March 11, 2011

National Aeronautics and Space Administration
Jet Propulsion Laboratory
California Institute of Technology

Tsunami-driven Traveling Ionospheric Disturbances (TIDs)

National Aeronautics and Space Administration
Jet Propulsion Laboratory
California Institute of Technology



From *Artru et al.,* 2005

GPS Ionospheric Remote Sensing Can "See" the Tsunami, potentially in real-time

National Aeronautics and Space Administration
Jet Propulsion Laboratory
California Institute of Technology

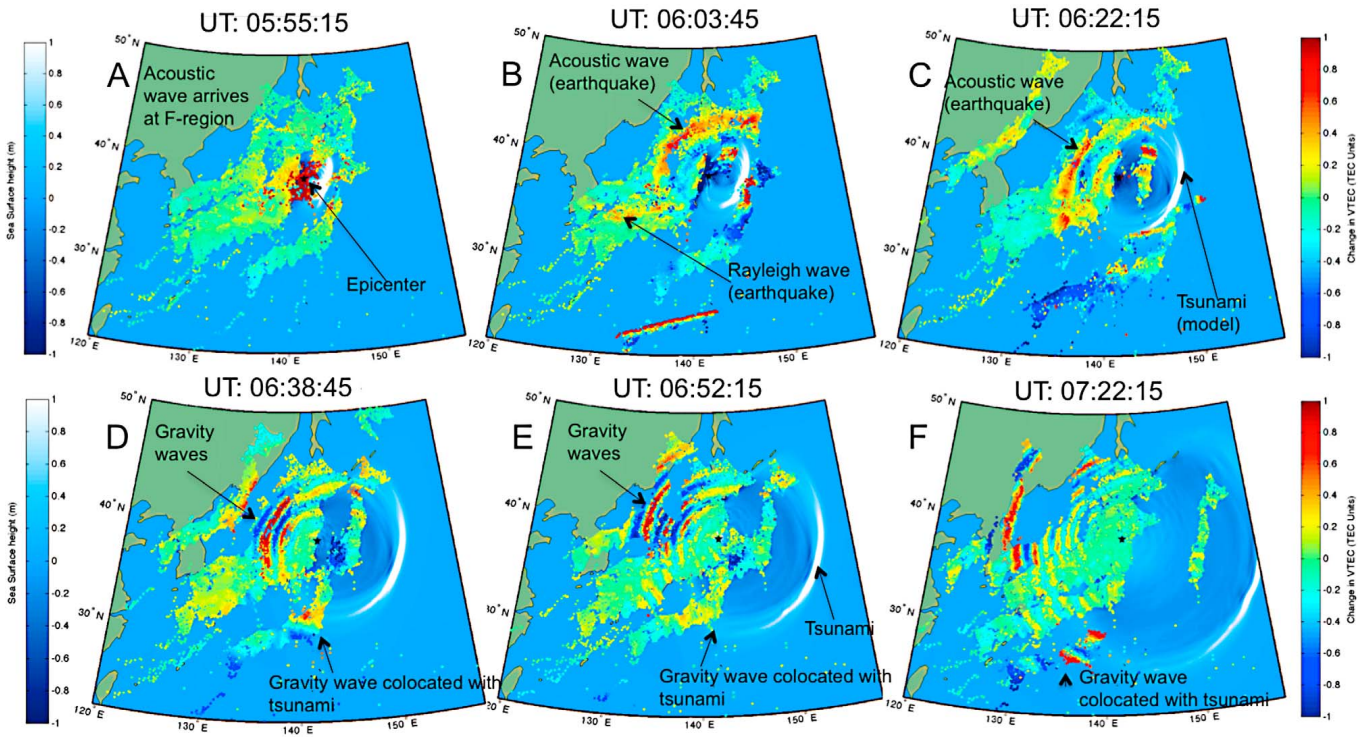
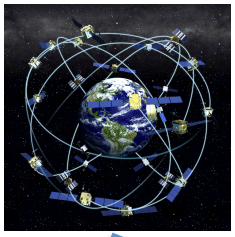


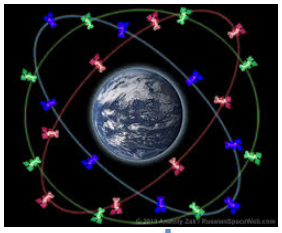
Figure 2. Map plots showing band-pass filtered VTEC (in units of TECU, right color bar) at ionospheric pierce points (IPPs) above Japan at different times on March 11, 2011. Each cluster of IPPs represents locations in the ionosphere where the signal from one GPS satellite, communicating with all GEONET receivers, passes through the *F* region peak at 300 km altitude. IPPs are plotted over sea surface heights from the Song tsunami model (in units of meters, left color bar) for comparison of wavefront positions in the ocean and ionosphere. These are frames from an animation available as dynamic content. (Animation S3)

Ionospheric signatures of Tohoku-Oki tsunami of March 11, 2011: Model comparisons near the epicenter David A Galvan, Attila Komjathy, Michael P Hickey, Philip Stephens, Jonathan Snively, Y Tony Song, Mark D Butala, Anthony J Mannucci, Citation : Galvan Radio Science 07/2012; DOI: 10.1029/2012RS005023

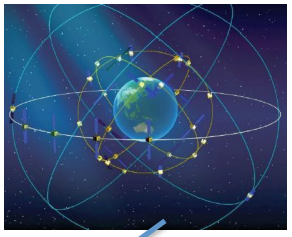


GPS (USA)

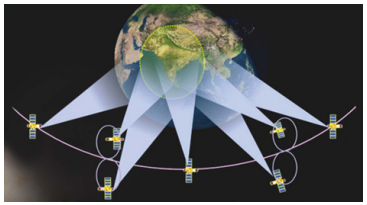
Galileo (Europe)



GLONASS (Russia)



Beidou (China)



IRNSS (India)

WHAT DOES THE FUTURE FOR GNSS LOOK LIKE?

Increasing international collaboration in the user community utilizing multiple GNSS together for improved coverage and science as new GNSS proliferate

What will be the next GNSS "amazing science?" Pinpoint prediction of natural hazards, weather?

New operational paradigms for next generation GNSS functionalities?

Radio Frequency Interference and spectrum issues are increasingly in importance for GNSS. How will the GNSS stakeholders work together on this?

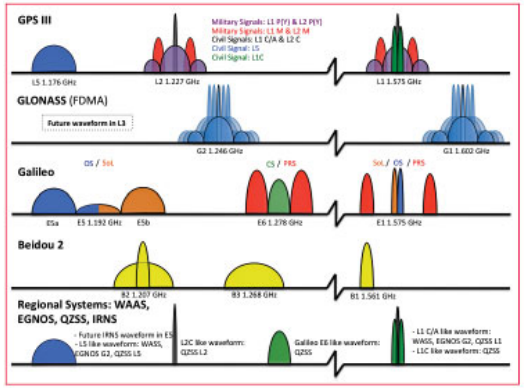


Figure 1. Signal spectrum of all GNSSes

http://mycoordinates.org/multi-gnss-positioning-campaign-in-south-east-asia/