Jet Propulsion Laboratory
California Institute of Technology

Technology Enables Science

ESTF 2015

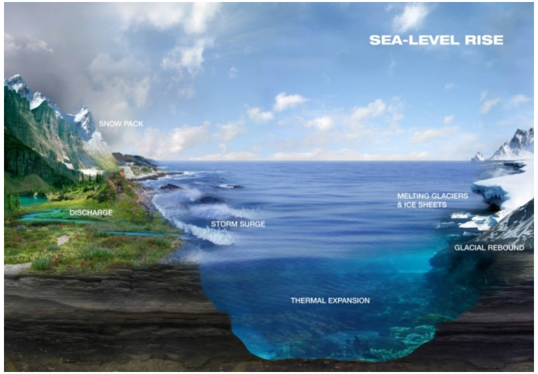
Lt. Gen Larry James, Deputy Director

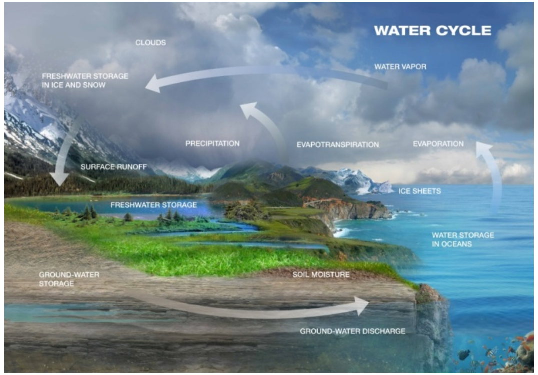
NASA Jet Propulsion Laboratory

California Institute of Technology

Understanding our Planet

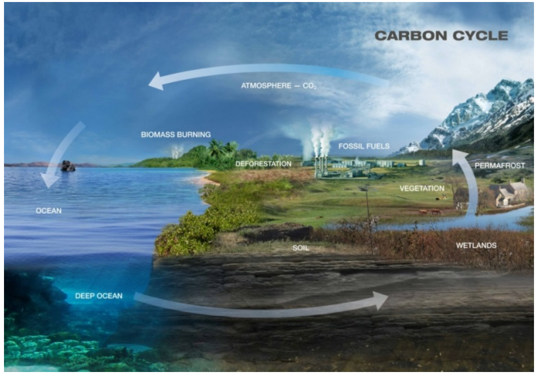
Will sea level continue to rise at the current rate?





Will water availability change in the future?

How are carbon storage and biodiversity changing?

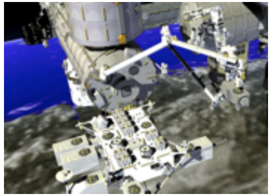


How can we better prepare for extreme events such as earthquakes, floods and volcanoes?

Missions Developing Scientific Capability

Carbon Cycle

OCO-2 (2014-)



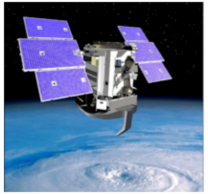
OCO-3 (~2017)

ECOSTRESS (~2017)

Water Cycle

SMAP (2015-)

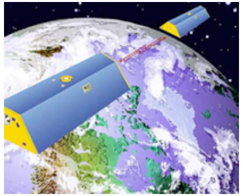
ASO (2013-)



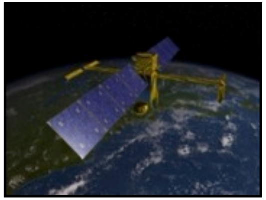
GPM & CloudSat (2006-)

Sea Level Rise

Jason series (1992/2001/ 2008/2015/2020/2025)



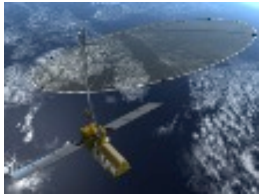
GRACE series (2002/2017)



SWOT (~2020)

Natural Hazards

UAVSAR (2007-)

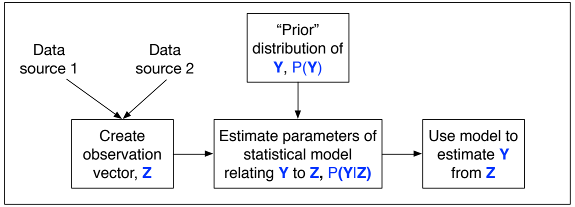


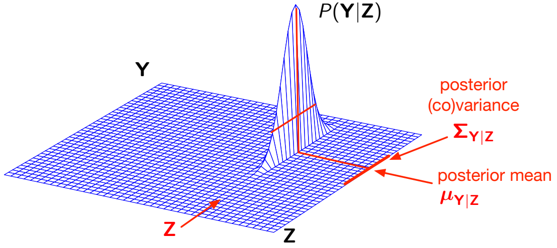
NISAR (~2020)

Example of Mission Infusion

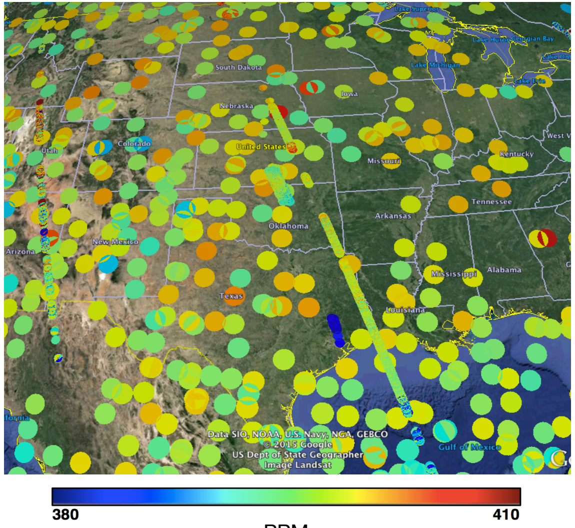
Multivariate Data Fusion and Uncertainty Quantification for Remote Sensing

- Spatio-Temporal Data Fusion (STDF) algorithm enables minimum uncertainty estimates of lower-atmospheric CO2 via complementary data sources (currently unobserved by any single instrument alone)

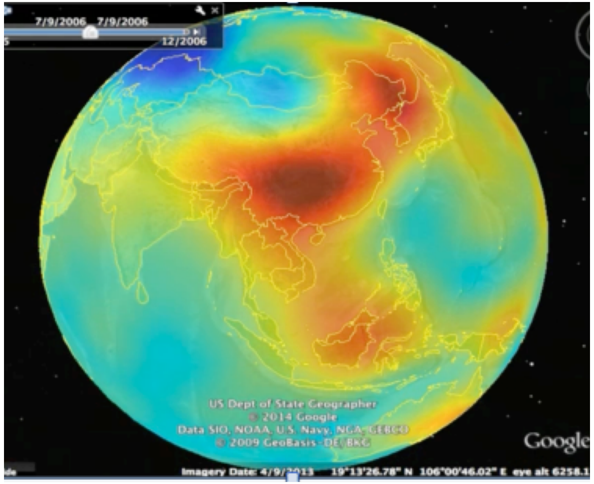




Statistical inference technology allowing multi-source spatial and temporal data fusion with quantified uncertainty



AIRS [large] and OCO-2 [small] footprints for spatio-temporal data fusion for lower-atmosphere CO2

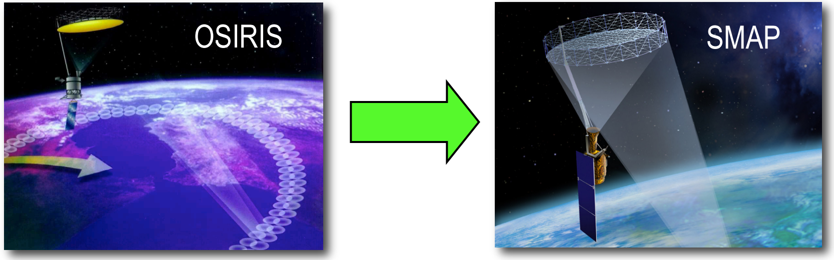


Spatio-temporal data fusion of AIRS/OCO-2 data estimating lower-atmospheric CO2 (preliminary result atmosphere level-1)

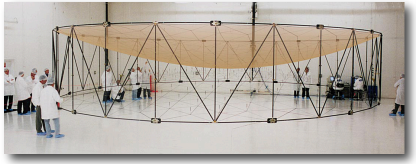
Example of Mission Infusion

Deployable Mesh Antenna for SMAP

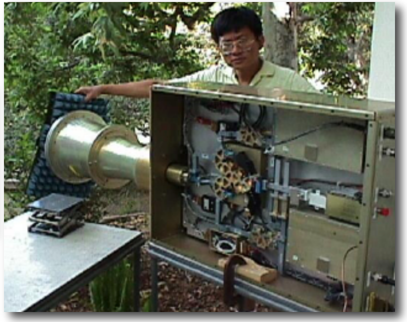
- Soil Moisture Active-Passive (SMAP) Mission uses L-band radar and radiometer together with a rotating mesh antenna for global soil moisture and freeze/thaw measurement
  - This measurement concept/technology was first proposed and developed by the 1998 IIP study at JPL called OSIRIS (Ocean-salinity Soil-moisture Integrated Radiometer-radar Imaging System)



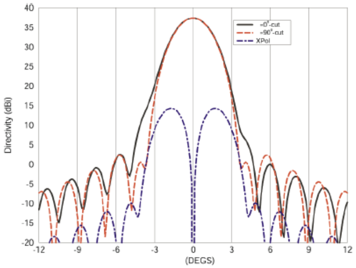
TRW AstroMesh antenna



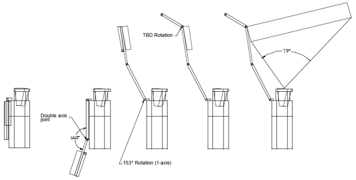
Outdoor testing of OSIRIS electronics & antenna Feed breadboards



- Accomplishments of the OSIRIS IIP study include:
  - Develop instrument performance requirements
  - Measure wire mesh emissivity to access applicability
  - Design electronic subsystems for radar and radiometer
  - Design antenna feeds and rotating mesh reflector and assess performance and calibration stability
  - Performance flight configuration and optimization study



Modeled antenna pattern

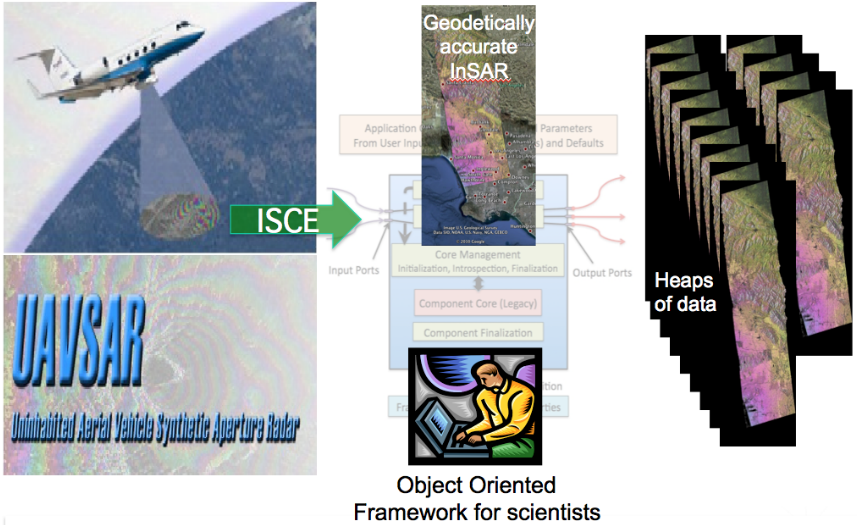


antenna deployment concept

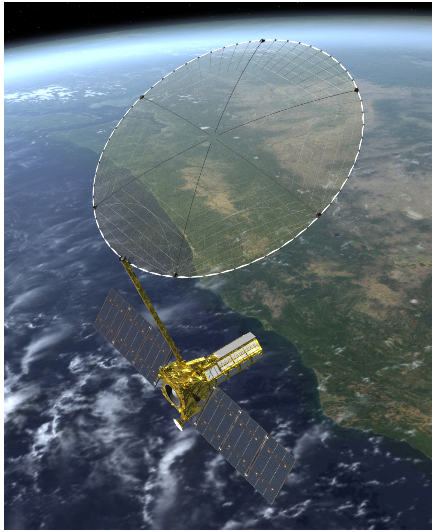
Example of Mission Infusion

ISCE is the Foundation for NASA-ISRO SAR (NISAR) Mission Processing

- InSAR Scientific Computing Environment (ISCE) will enable processing NISAR's polarimetric data into global surface change maps in tectonic areas, disturbance maps in ecosystems, and velocity maps in the cryosphere



Distributed workflow, image reading, segmentation, and sampling technology enabling large-scale, cloud computing-based inteferogram product generation

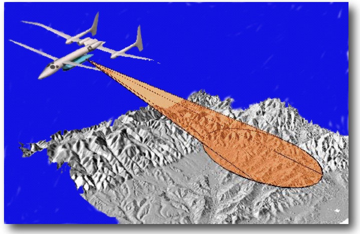


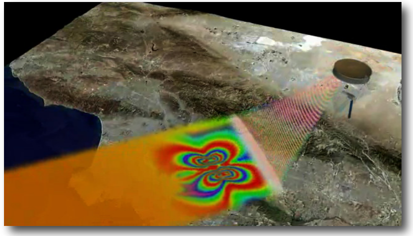
Map highlights areas where the model predicts the greatest ground deformation (motion) has occurred

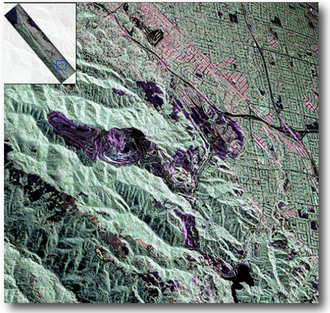
Example of Mission Infusion

UAVSAR & Digitally-Calibrated T/R Modules for NISAR Measurement Technique/Technology

- NASA India SAR (NISAR) Mission will use an L-band polarimetric synthetic aperture radar with repeat-pass interferometry (INSAR) for global earth surface and ice sheet deformation measurements
  - The 2003 IIP study at JPL called UAVSAR serves as the implementation concept and technology testbed, and airborne simulator, of the NISAR INSAR

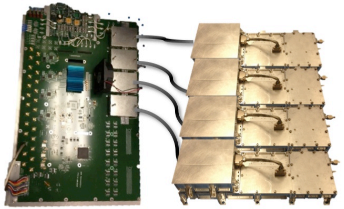






UAVSAR polarimetric image of San Andreas Fault 02/12/2008

- The 2010 ACT "digitally calibrated L-band transmit/receive module" technology development task provides phase- and amplitude-stable signals to enable precision beamforming SweepSAR architecture for NISAR's repeat-pass interferometric radar applications



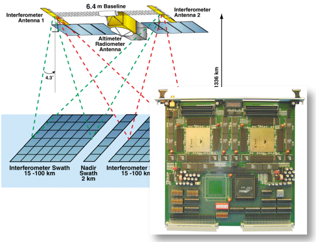
quad channel first-stage processor

Digitally calibrated transmit/receive modules

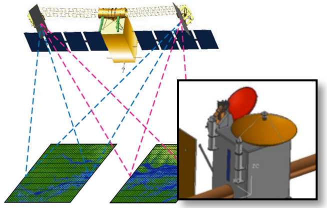
Example of Mission Infusion

Several Enabling ESTO Technologies for SWOT

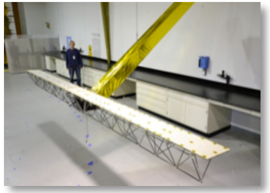
Advanced Ku-Band Altimeter for Oceans Studies
IIP-98: Lee-Lueng Fu



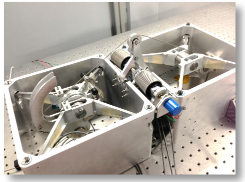
Ka-band SAR Interferometry Studies for the SWOT Mission
IIP-07: Lee-Lueng Fu



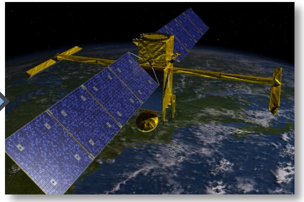
Large Deployable Ka-Band Reflectarray for the SWOT Mission
ACT-08: Mark Thomson



Precision Deployable Mast for the SWOT KaRIn Instrument
ACT-10: Gregory Agnes

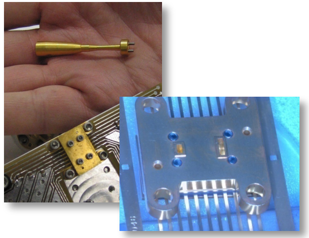


SWOT Mission

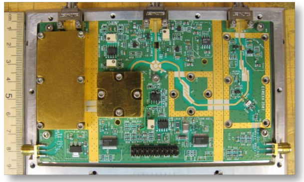


Technology Advancement & Risk Reduction

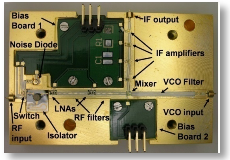
Miniature MMIC Radiometers
ACT-05: Pekka Kangaslahti



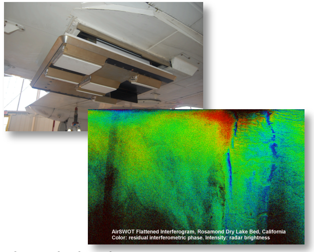
A Low Power, High Bandwidth Receiver for Ka-band Interferometry ACT-08: Dani Esteban-Fernandez (Co-I)



Advanced Component Development to Enable High-Frequency SWOT Radiometers ACT-08: Shannon Brown (Co-I)



AirSWOT: the SWOT Cal/Val Platform
IIP-10: Ernesto Rodriguez

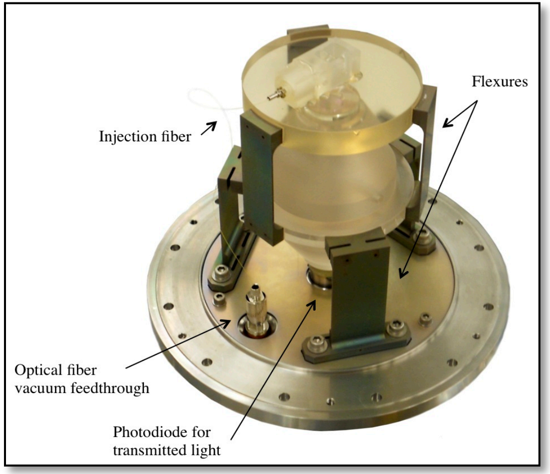


Example of Mission Infusion

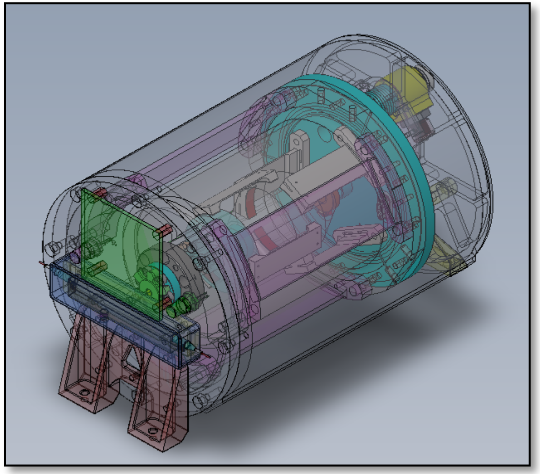
Laser Ranging Technology to Fly on GRACE-FO

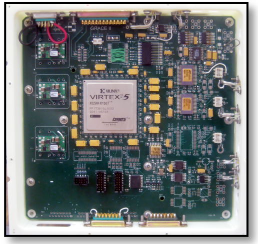
- A prototype laser frequency stabilization subsystem has been developed under IIP-07 to provide the length reference for inter-satellite laser range measurements. This has been included on the GRACE Follow-On mission in a technology demonstration to measure changes in distance between spacecraft with accuracy 20 times better than the primary microwave ranging instrument, which will show improved sensitivity to changes in water mass distribution.

Prototype laser frequency stabilization subsystem



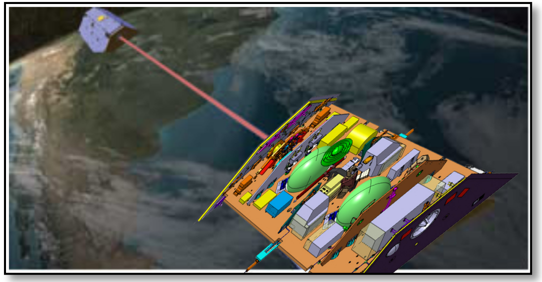
Configuration for GRACE-FO spacecraft





Laser locking control board

Location of laser frequency stabilization subsystem on GRACE Follow-On satellite

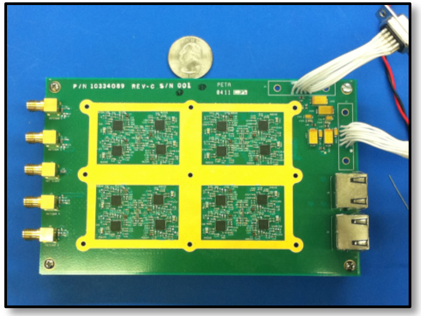


Example of Mission Infusion

RF Processor Technology to Fly on COSMIC-2

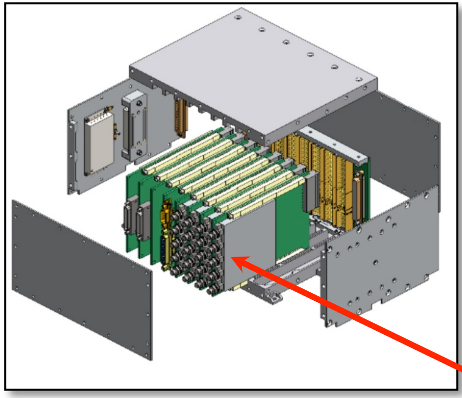
- A new, next-generation RF processor for digital beam-forming of Global Navigation Satellite System (GNSS) signals will be part of the TriG GNSS receiver on the Constellation Observing System for Meteorology, Ionosphere and Climate-2 (COSMIC-2) Mission. It will also be the payload on the Gravity Recovery and Climate Experiment Follow-On (GRACE-FO) Mission.
- The robust, tunable, broad-band RF processor will track GNSS signals at four frequencies – 1175, 1227, 1575, and 1606 MHz, one more than required – from a package size 4 times smaller than current RF processors.

GNSS RF processor prototype board



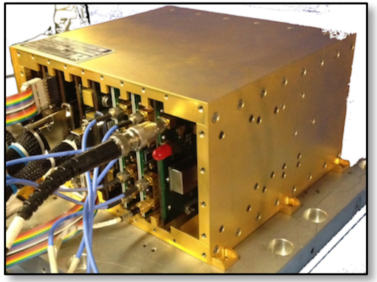
Developed under ESTO's ACT-08, the board was tested for environmental qualification to TriG's flight requirements

Expanded View of TriG Receiver



GNSS RF Beam-forming Processors (4 boards)

TriG Receiver

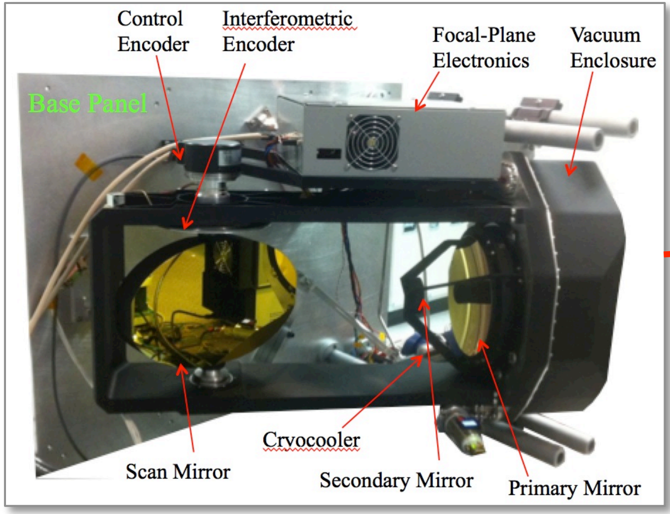


Compared to current NASA flight hardware:
- ***25% size***
- ***70% power***
- ***Capable of receiving all GNSS signals.***

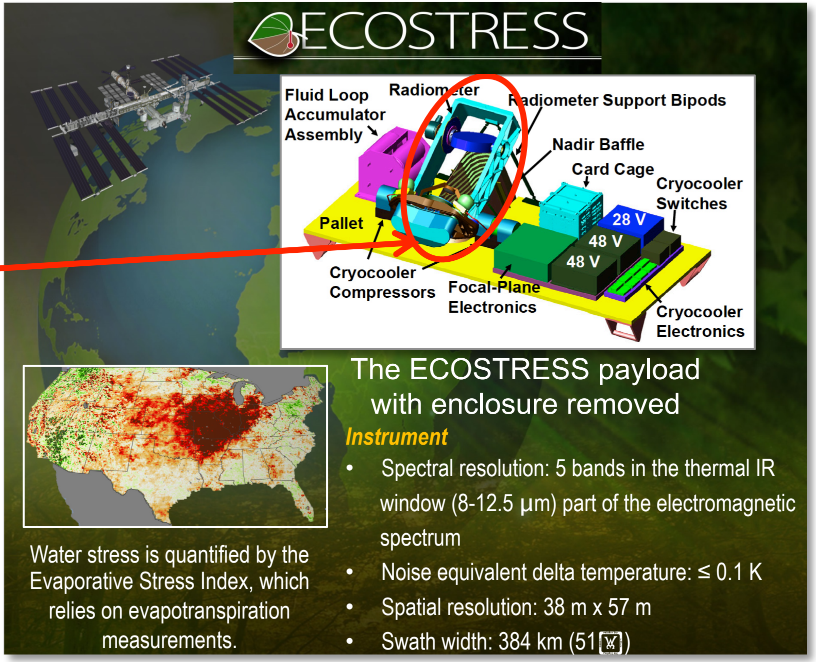
Example of Mission Infusion

PHyTIR Instrument for EVI-2 ECOSTRESS

- The Prototype HyspIRI Thermal Infrared Radiometer (PHyTIR) developed under IIP-10 is the instrument for the NASA's Earth Venture ECOSTRESS experiment on the International Space Station to study plant-water dynamics and how ecosystems change with climate.



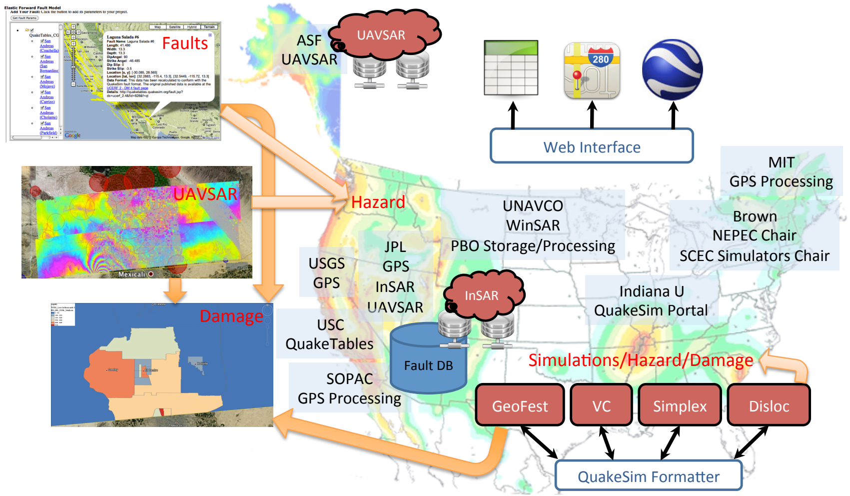
PHyTIR instrument developed Under the 2010 Instrument Incubator Program (IIP-10)



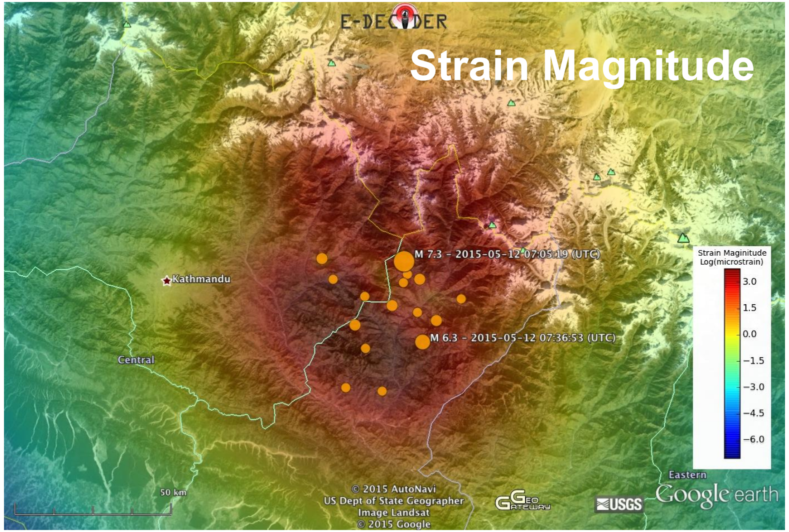
Example of Application Infusion

QuakeSim/GeoGateway 12 May 2015 M 7.3 and 6.3 Aftershocks (E. Kathmandu)

- Rapid deformation model produced by QuakeSim/GeoGateway/E-DECIDER, based on the moment tensor solution provided by the US Geological Survey, within minutes during satellite observations



Distributed infrastructure technology integrating large and heterogeneous data and models utilizing cloud computing

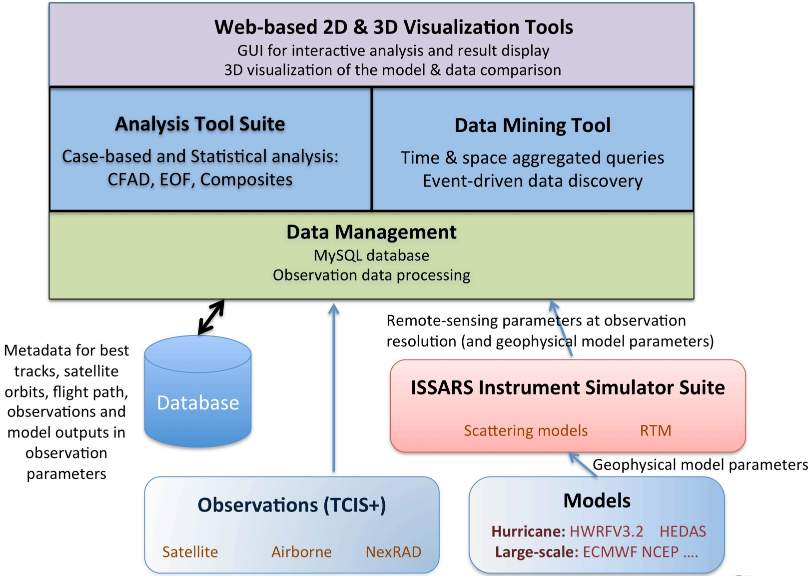


Map highlights areas where the model predicts the greatest ground deformation (motion) has occurred

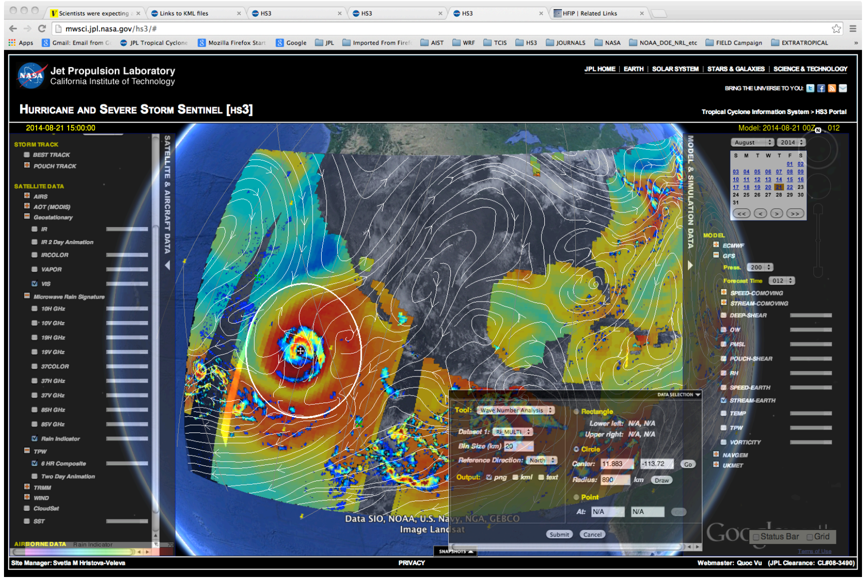
Example of Application Infusion

Tropical Cyclone Information System (TCIS) for Hurricane Forecast Improvement

- TCIS will operate during the 2015 hurricane season supporting NOAA's SHOUT airborne campaign

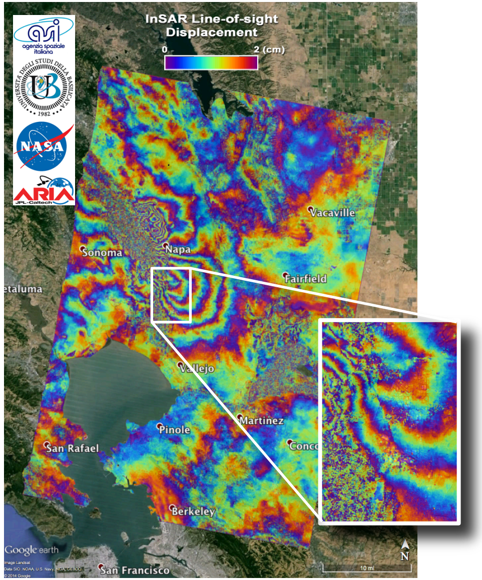


Processing technology enabling multi-source data fusion across hurricane forecast models, satellite data, and in situ sensors for real-time interaction of complex systems

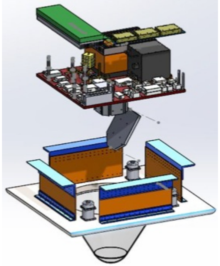


On-line analysis capability facilitating evaluation of operational hurricane forecasts

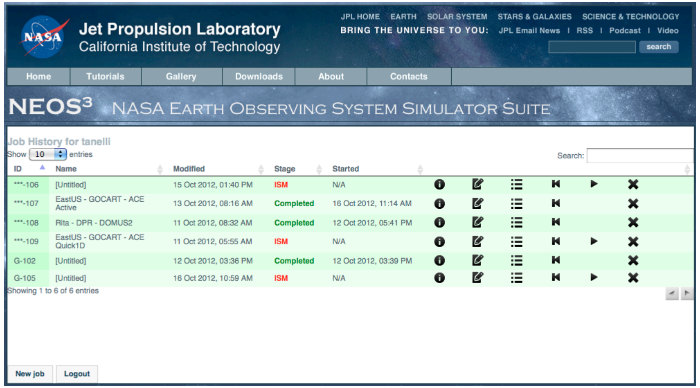
Earth Science: New Airborne Instruments and Emerging Technologies



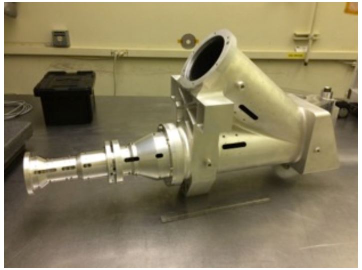
Advanced Rapid Imaging and Analysis



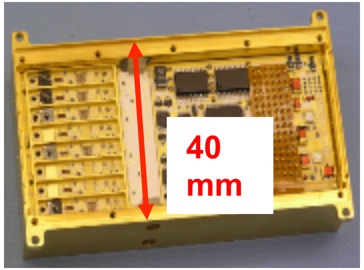
Ka-Band Doppler Scatterometer



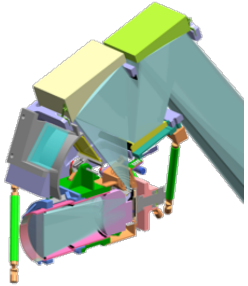
NASA Earth Observing Simulator Suite



Compact Florescence Imaging Spectrometer



Three-band Cloud and Precipitation Radar



Snow and Water Imaging Spectrometer

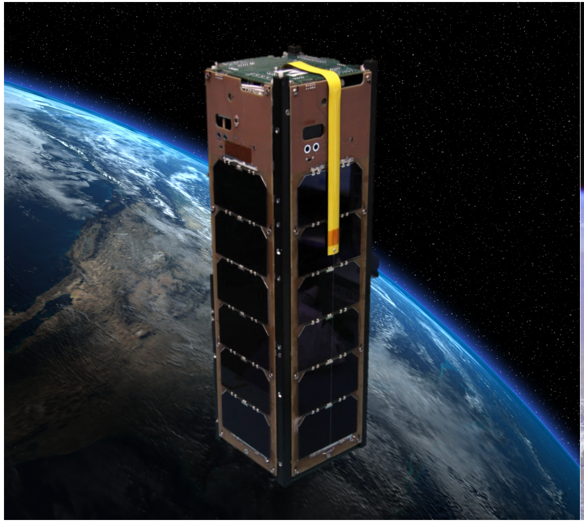
JPL Airborne Instruments

Half of them were developed through ESTO Programs

Support for U-Class Satellite Development

JPL Developed Technology Payloads Validated on U-Class Spacecraft

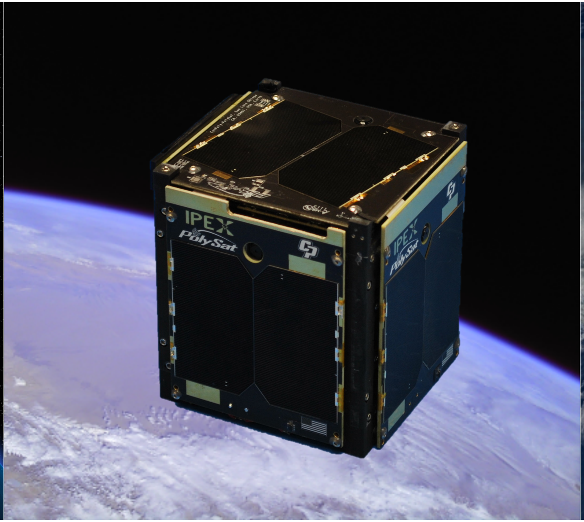
GRIFEX
Launched VAFB: Jan. 31, 2015



ROIC Technology for GEO-CAPE

Imaging technology enabling atmospheric chemistry and pollution transport science from GEO

IPEX
Launched VAFB: Dec. 5, 2013



Autonomy Technology for HyspIRI

Autonomous science product generation and near real-time product delivery technologies

M-Cubed/COVE-2
Launched VAFB: Dec. 5, 2013

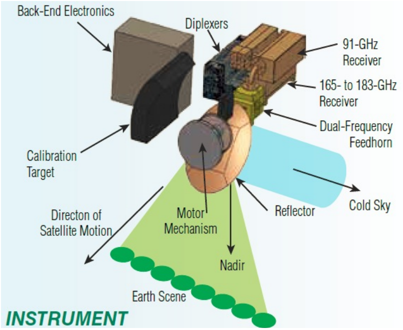
Polarimetry Processing for ACE

On-board instrument signal processing technology to support aerosol and climate science

Support for U-Class Satellite Development

JPL Developed Payloads on Future U-Class Spacecraft

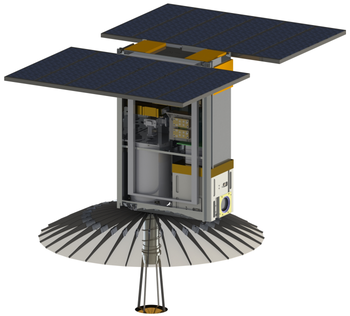
TEMPEST-D
Phase-A Development



5 Frequency mm-Wave radiometer

Technology demonstrator measuring the transition of clouds to precipitation

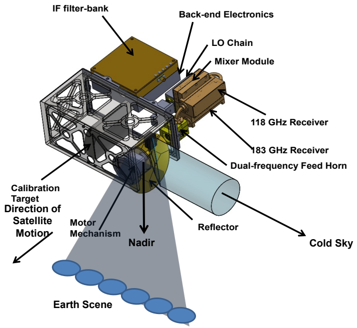
RainCube
Phase-A Development



Ka-band precipitation radar

Prototype of radar constellation for temporal precipitation profiling

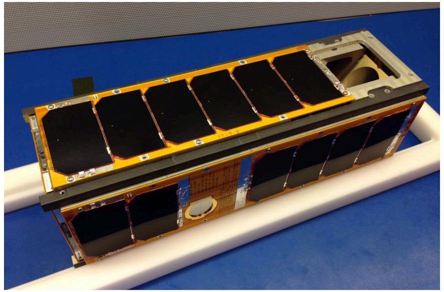
MASC
Phase-A Development



118 GHz and 183 GHz microwave radiometer

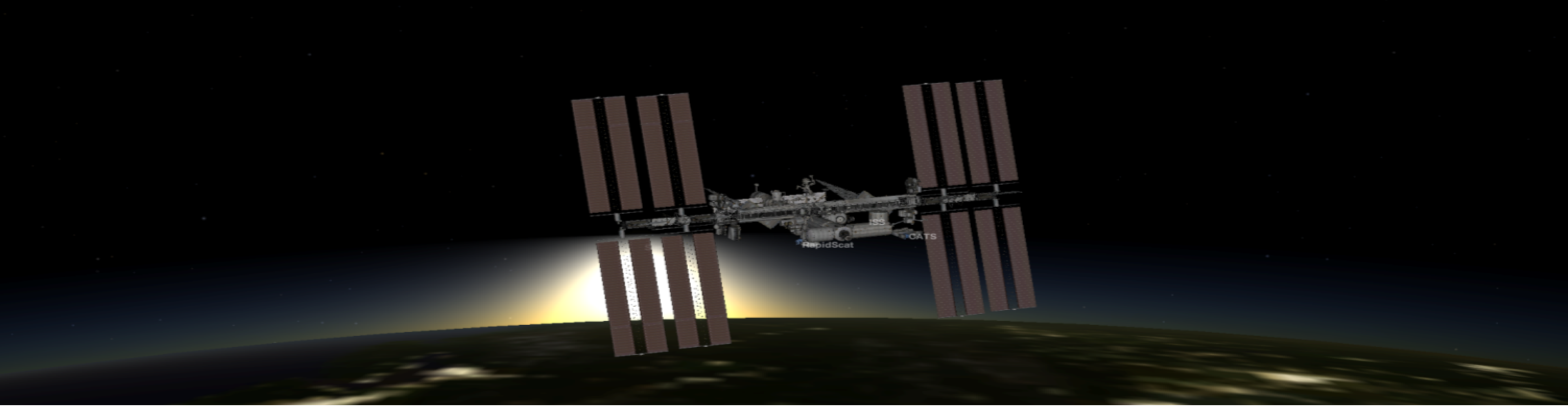
Cross track scanning atmospheric sounder

RACE
Antares Launch Failure

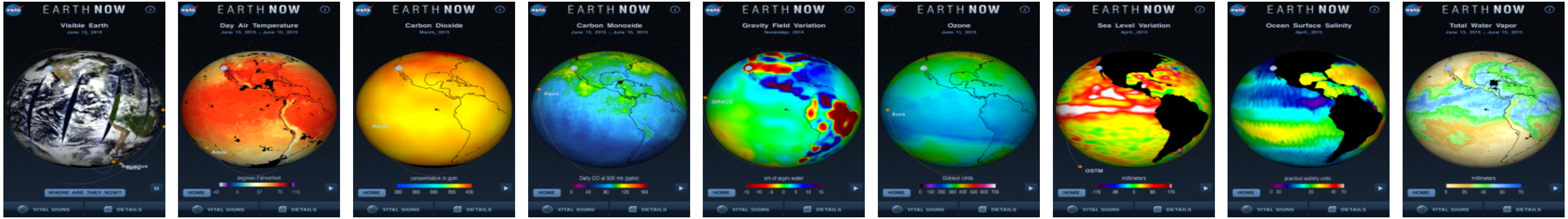


183 GHz microwave radiometer

Measuring liquid water path and precipitable water vapor



Eyes on the Earth (Mac & PC) and **Earth Now** (iOS & Android) allow the public to ride onboard with our spacecraft and explore the data they are collecting about our home planet. Visit *http://eyes.nasa.gov/earth*



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