GOES Instrument of Opportunity (IOO)

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IOO described

- The Instrument of Opportunity is a modest "passenger seat" on the Earth-facing side of the GOES satellites (not for microwave sounding)
- IOO slots on GOES-I/M (1994-2001) and GOES-N/Q (2003-2008)
  - No takers
  - Last chance on GOES-P/Q (if a Q)
- What about an IOO on GOES-R and beyond (2012+)?

IOO interface on GOES-N/Q

- IOO IRD
  - "Interface Requirements Document for Geostationary Operational Environmental Satellites (GOES) N-Q Instrument(s) of Opportunity", Revision A, Feb. 1999, HSC 98091RP/Databank GA27082, 76 pages.
- 100 x 60 x 40 cm box on optical bench
  - 50 x 50 cm aperture - 100's meter visible resolution
  - No dark face for cryo-cooling - poor thermal IR
- 50 kg (35 + 15 kg = box + externals)
- 150 watts (250 watt option)
- Semi-annual N-S flip -- point or scan or full disk
- Multi-use Data Link to Wallops -- must get data from there
- 100 kilobits/sec (680 kbps option) -- data rate limited!

IOO location on GOES-N/Q

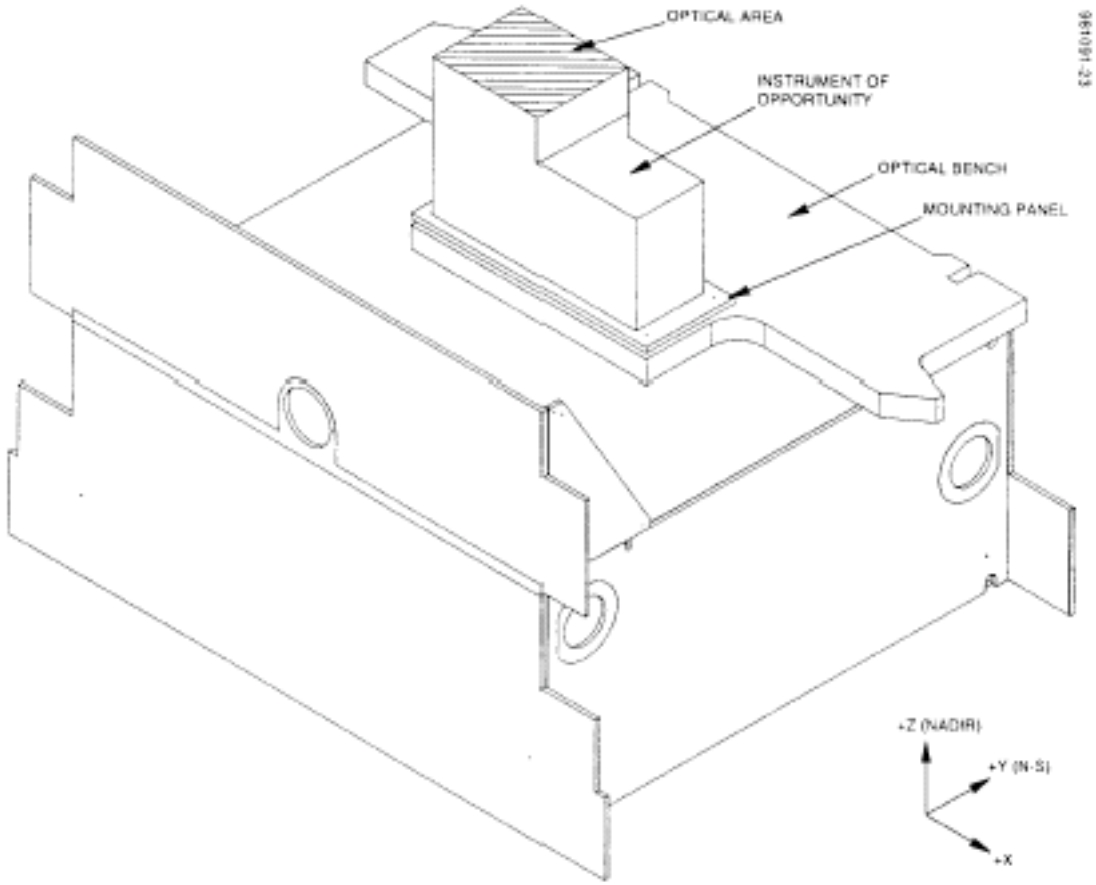


Figure 3-2. Instrument(s) Dimension Envelope With Respect to the GOES Spacecraft

IOO dimensions on GOES-N/Q

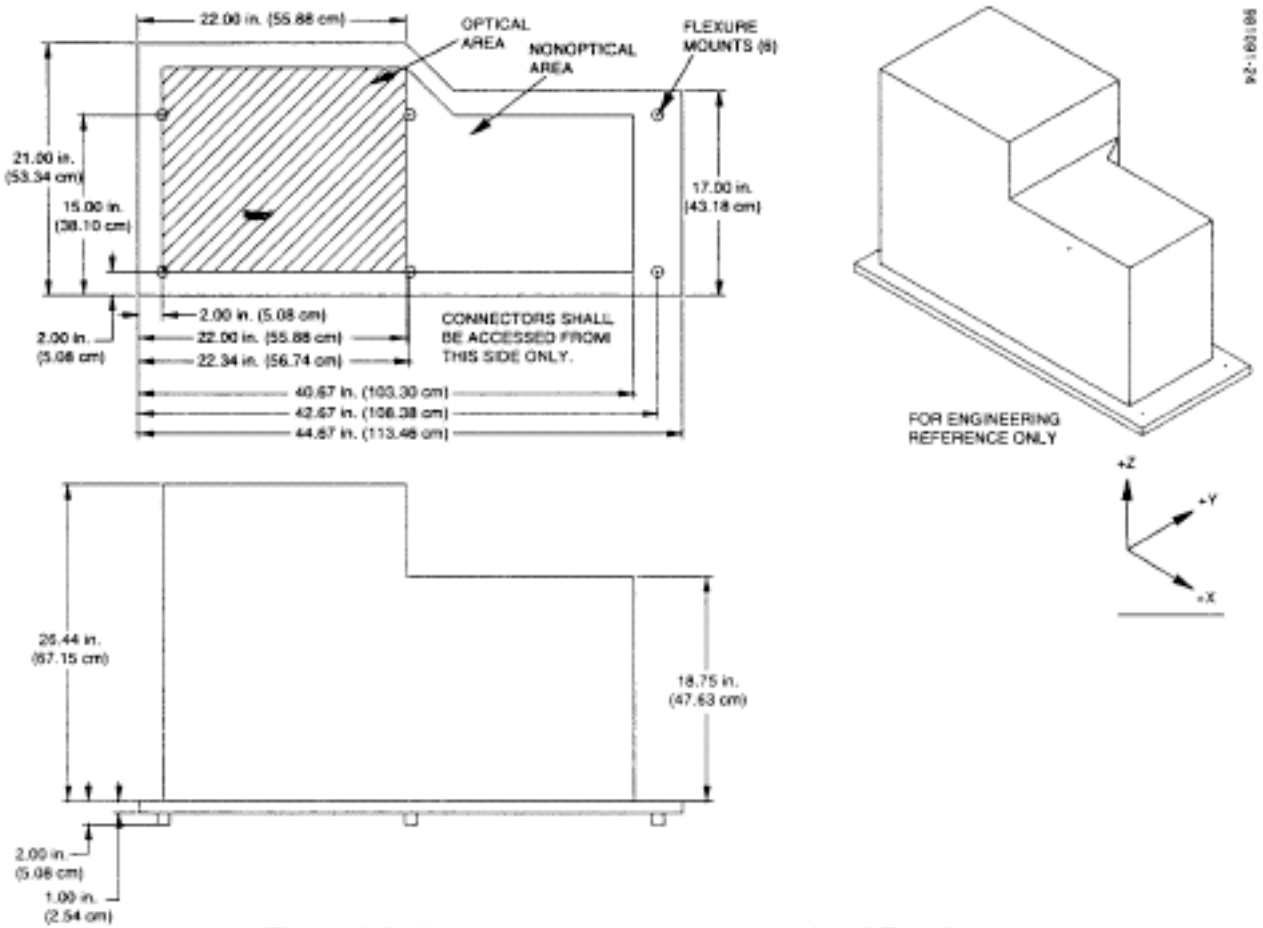


Figure 3-3. Detailed Instrument(s) Dimensional Envelope

The IOO advantage

- Continuous 24/7/365 observations
- Unpredictable conditions and events
- On-demand observations
- Diurnal cycles
- Supplement LEO
- Responsive to new requirements
- Prove new technology

IOO Environmental Targets

- Lightning
- Volcanoes - ash & vapor
- Ozone
- Clouds & aerosols
- Fires & smoke
- Ocean color & coastal conditions
- Event-of-the-day

14 Responses to IOO RFI

HOUSEKEEPING
- GPS-based On-board Orbit Determination
- Geo-Environment Monitor - contamination, etc.

PARTICLES & FIELDS
- Low-Energy Charged Particle Imaging Spectrometer
- Solar Wind Neutral Atom Imager
- Electric Field Measurement

SPECTROSCOPES
- Far-Infrared Spectroscopy of the Troposphere
- Tropospheric Chemistry - carbon monoxide, ozone and aerosols
- Full Disk Imaging Etalon Spectrometer - temperature profiles, chemistry, etc.

SPECIAL IMAGERS
- Low Light Imager
- Fire Detection Camera
- Ocean Color Instrument
- Volcanic Camera
- Lightning Mapper
- Extended Special Events Imager

IOO RFI Candidates (1 of 3)

Instrument	Purpose	Mass	Power	Data Rate	Dimensions	S/C Location	FOV
Electric Field Measurement	Electric field determines flow of mass, energy and momentum within the near earth plasma environment.	Total : 10.9 kg GDU: 4.6 kg (2) Controller: 1.7 kg	9.9 W	1kbps – 5kbps	GDU: 370x190x210 mm Controller: 200x160x100 mm	Anywhere	?
PiVoT	GPS-based On-board Orbit Determination	<2000 grms	10 W	?	12.7x19.1x9.6 cm plus Nadir Mounted Antennas	PiVoT box: anywhere Antennas: Nadir	Nadir
Geostationary Observatory for Tropospheric Air Chemistry (GeoTRACE)	Investigates the effect of urban and regional weather and chemistry on the global pollutants: Carbon Monoxide, ozone and aerosols	IR Radiometer – 37 kg UV/Vis Spectrometer – 40 kg	300 W	50 Mbps	IR Radiometer: 0.7x04x0.5 m UV/Vis Spectrometer: 0.8x0.8x0.5 m	Nadir	19 degree cone centered on Nadir
Extended Special Events Imager (ESEI)	High spatial and temporal resolution measurements of suspended organic material within the ocean with emphasis on natural and anthropogenic pollution in coastal regions.	25 kg	60 W	80 kbps	30x40x60 cm	Nadir	Nadir
VOLCAM	Conduct research on volcanic clouds and eruption precursors for natural hazards and aviation safety.	Sensor + Electronics: 13 kg Stabilization System: 11 kg	41 W	Day: 150 kbps Night: 2 kbps	Sensor: 40x40x27 cm Electronics: 15.3x15.3x20.4 cm	Nadir	19 degree cone centered on Nadir
Low Light Imager	A high-resolution panchromatic imager with a dynamic range in excess of 1E7 that can resolve cloud and plume boundaries under most day and night observation conditions.	45 kg	40 W	450 kbps	Sensor: 68x68x50 cm Electronics: 30x30x20 cm	Nadir	19 degree cone centered on Nadir
FireSAT	Develop a continuous mapping of vegetation fires in forests, grasslands, and agricultural fields.	23 kg + 10-15 kg for precision pointing	100 W	2 Mbps	?	Nadir	19 degree cone centered on Nadir

IOO RFI Candidates (2 of 3)

Instrument	Purpose	Mass	Power	Data Rate	Dimensions	S/C Location	FOV
Low-Energy Charged Particle Imaging Spectrometer (LEPIS)	Targets lower (20 to 1000 keV) energy particles than the current SEM. Also provides pitch angle data currently unavailable from GOES.	< 0.7 kg	< 1 W	?	150x150x85 mm	Sun viewing Linear array aligned N-S	
Lightning Mapper Sensor	Characterize development and intensity of the convection and simultaneous measurement of lightning activity over a large portion of the Americas and adjacent oceans.	35 kg	120 W	100 kbps	Sensor + electronics: 50x37.5x25 cm Sun Shield: 20x37.5x50 cm	Nadir	4.54 deg x 7.25 deg (x2)
Geostationary Far-Infrared Spectroscopy of the Troposphere (Geo-FIRST)	Michelson Interferometer covering virtually the entire IR spectrum 4-100 micro meters	50 kg	50 W	?	50x50x50 cm	Nadir	
GOES Environment Monitor (GEM)	Suite of sensors to measure key elements of the GOES external environment. Provides orbit insertion and orbit transfer diagnostics and contribute to NASA orbital environment data base. Total Pressure Sensor (TPS), IR Camera (IC), Monitor External Environment Contamination (MEEC), Optical QCM and Solar QCM	TPS: 3.6 kg IC: 6.4 kg MEEC: 12 kg	TPS: 4 W IC: 26 W MEEC: 31 W	?	TPS: 4x4x11 in IC: 0.1x0.1x0.1 ft MEEC: 9.5x8x11 in	Anywhere	IR: 10 deg
Full Disk Imaging Etalon Spectrometer (FDIES)	4 different versions: •Carbon Monoxide, tropospheric temperature and cloudiness (CO, TT & C) •Aerosol and cirrus polarization profiler, cloud top height and CO2 column (A&CPP, CTZ & CO2) •Tropospheric and column O3, tropospheric temperature and claudiness (T&C O3, TT, C) •Temperature, claudiness & humidity sounder (T,C & H)	CO,TT&C: 18.7 kg A&CPP, CTZ & CO2: 32.5 kg T&C O3, TT, C: 30 kg T,C & H: 28.7 kg	CO,TT&C: 55 W A&CPP, CTZ & CO2: 25 W T&C O3, TT, C: 85 W T,C & H: 85 W	745 kbps	CO,TT&C: 14x11x2 in A&CPP, CTZ & CO2: 20x12x3 in T&C O3, TT, C: 14x11x4 in T,C & H: 12x12x4 in	Nadir	

IOO RFI Candidates (3 of 3)

Instrument	Purpose	Mass	Power	Data Rate	Dimensions	S/C Location	FOV
Solar Wind Neutral Atom Imager	Image low energy outflow from Earth's Ionosphere	20.75 kg	13.1 W	0.5 kbps	57.4x39x41.1 cm	Sun viewing	8 deg x 90 deg
Ocean Color Instrument	French contribution. Response is late, due 10/13	30 kg	60 W	15 Mbps for 150 spectral bands 1.5 Mbps for 15 spectral bands	600 mm x 300mm x 300 mm	Nadir	18 deg

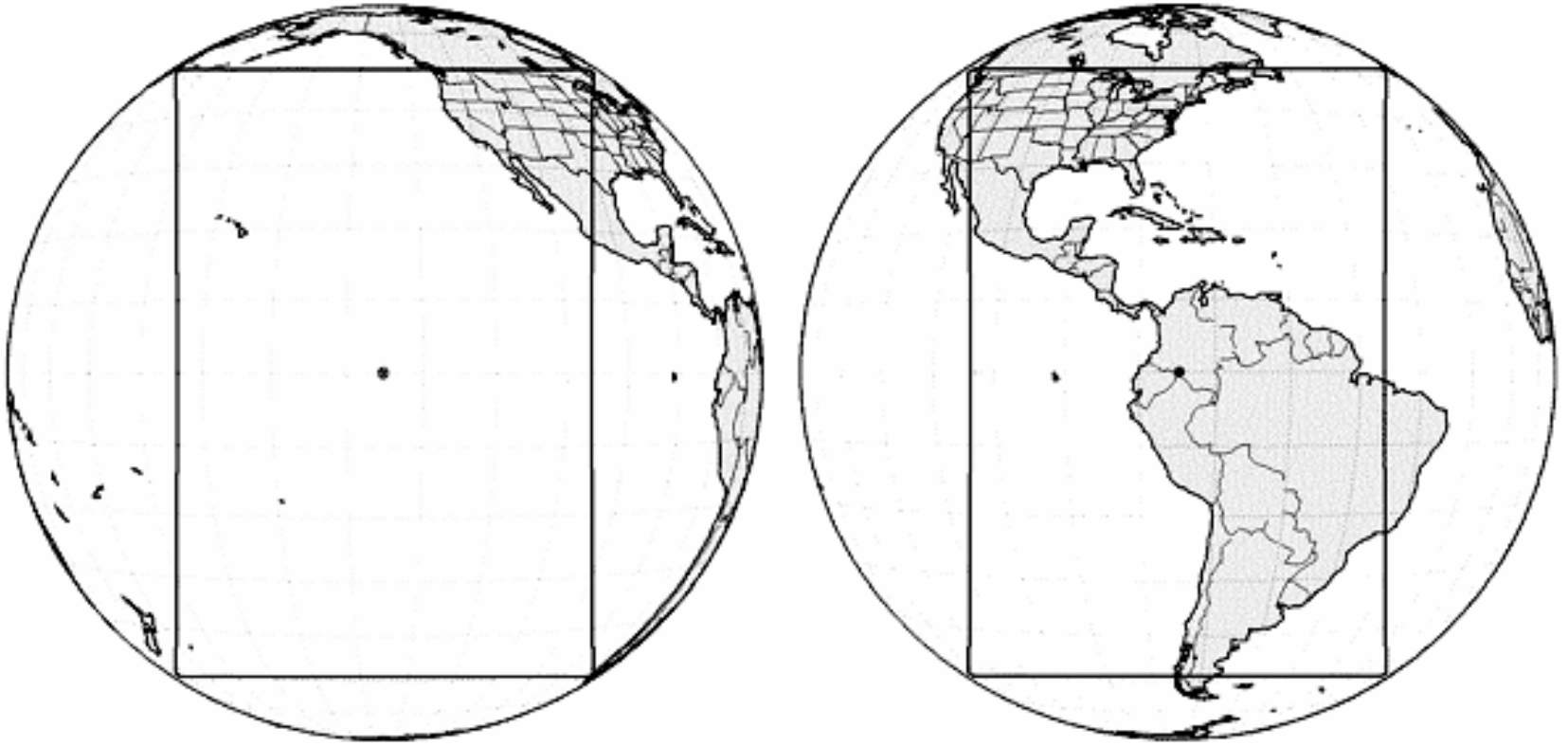
Previous IOO candidates (mid-90's)

- Lightning Mapper Sensor (LMS)
- Volcanic Camera (VolCam)
- Special Events Imager (SEI)
- High Definition Television (HDTV)

Lightning Mapper Sensor (LMS)

- Detects lightning-flash oxygen, day & night
- Associated with strong updrafts within severe storms - NWS value
- Well demonstrated in LEO
- Championed by Hugh Christian and Steve Goodman at NASA-MSFC

LMS view



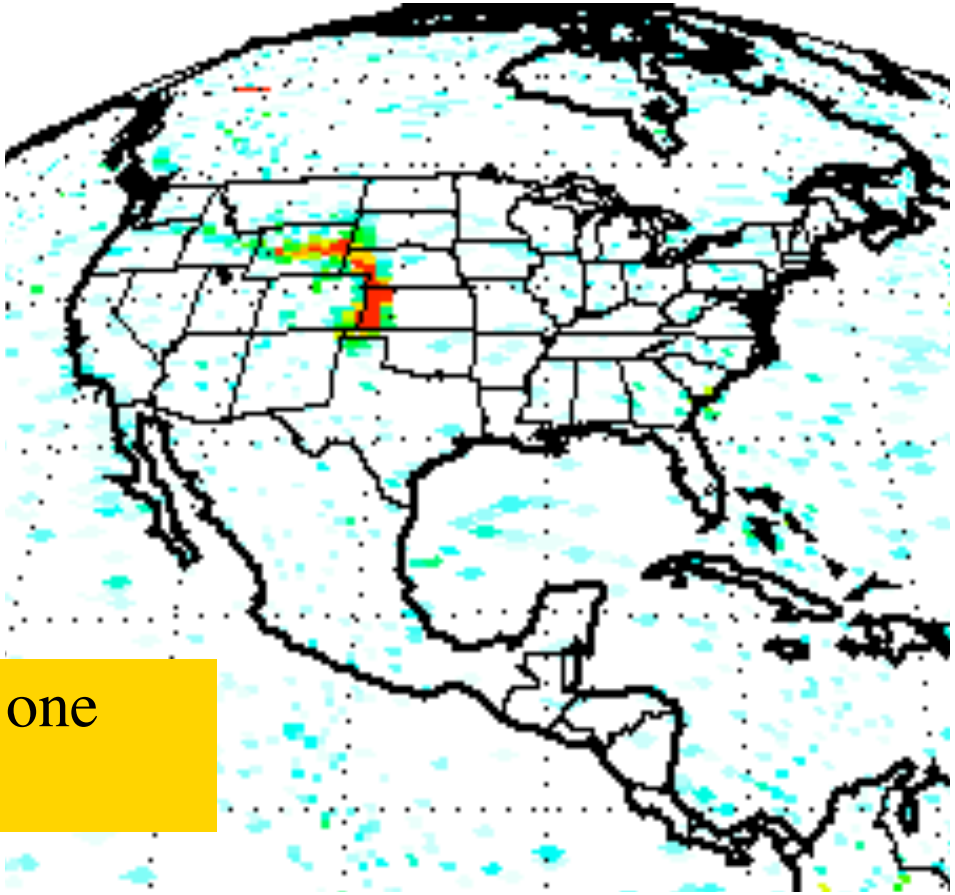
GOES-WEST (10 km, 1 min resolution) GOES-EAST

Volcanic Camera (VolCam)

- Detects ozone, ash ,dust, smoke & SO2 by solar absorption in multiple shortwave bands
  - maybe 11/12 micron split window for night, too
- Hazard detection - FAA value
- Well demonstrated in LEO
- Championed by Arlin Kueger at NASA-GSFC (now at UMBC-JCET)
- Uncooled microbolometers suggested, too

VolCam view

10 km, 15 min resolution (5 min local refresh)

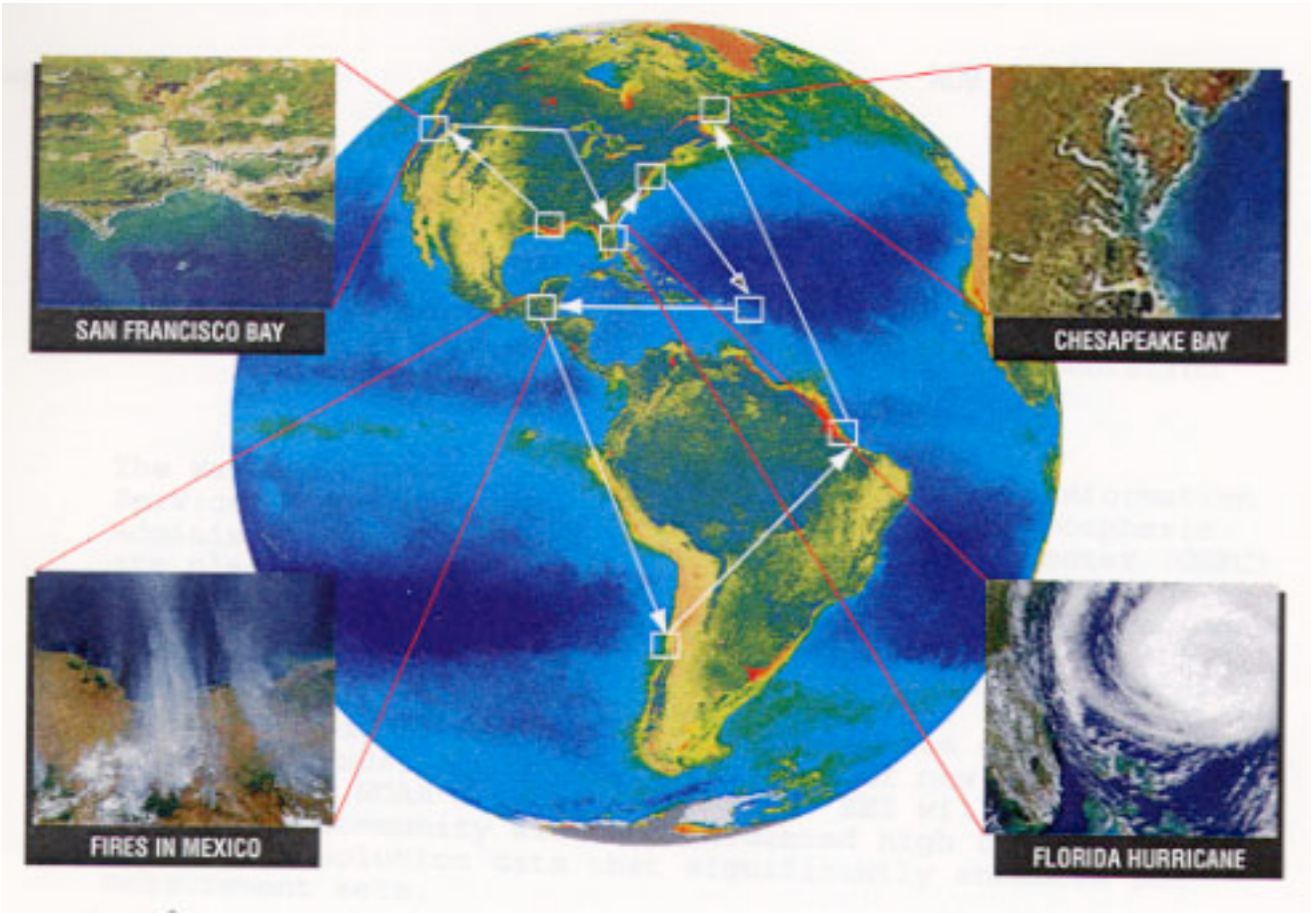


St Helens SO_2 cloud one day after eruption.

Special Events Imager (SEI)

- Detects ocean & coastal water color, NDVI, clouds & aerosols with multi-spectral color
- Ocean science & hazards - NOAA & NASA value
- Similar to LEO instruments
- Championed by Wayne Esaias (NASA-GSFC) & Chris Brown (NOAA-NESDIS)
- Combo with VolCam suggested, too

SEI view



300 m, 10 min resolution, 300 km FOV

High Definition Television (HDTV)

- Space-qualified HDTV color camera
- Event-of-the-day -- FEMA, CNN, Weather Channel value
- Similar to HDTV cameras on Shuttle, Space Station & AVStar (Malin)
- Championed by Malcomb LeCompte (Astrovision) - will fly independently in 2003 & 2005

HDTV view

10 km, 5 min resolution on GOES, full disk

1 km, 1 min resolution on AVStar, mesoscale FOV

IOO GOES program requirements

- Value to NOAA
- NOAA approval
- Fit in allocation constraints
- Independently funded
- Meet launch schedule
- No risk to mission or operations

IOO lessons learned

- Good values for science & society
- Interested parties
- Mature technology
- Programmatic Difficulties
  - Outside funding: several $10M's
  - Long lead time: 8-10 years

IOO schedule - GOES-P example

- 2002 - make proposal, get NOAA approval
- 2003 - funding, S/C contract mods, design IOO
- 2004 - build instrument, deliver test plan
- 2005 - deliver flight model IOO
- 2006 - pre-launch tests
- **2007 - GOES-P launch readiness**
- 2008 - GOES-P launch & post-launch testing
- 2009 - on-orbit storage
- 2010 - GOES-P operations begin at TBD station

IOO Options for GOES-R

- No IOO -- no cost
- Unstructured IOO -- business as usual
- Activate the IOO slot -- program commitment
  - **Establish a new operational mini-instrument**
    - e.g. Special Event Imager, Lightning Mapper, etc.
    - Keep the unstructured IOO slot for future technology
  - Fund a competitive program for series of IOOs
    - 2006-7 -- proposals & awards
    - 2012-4 -- launch IOO#1 on GOES-R; IOO#2 on GOES-S
- GOES-R users' requirements for "IOO"?
  - What new geo-based data products needed in 2010's?
  - **If a new operational mini-instrument, which one with what benefits?**