National Polar-orbiting Operational Environmental Satellite System (NPOESS)

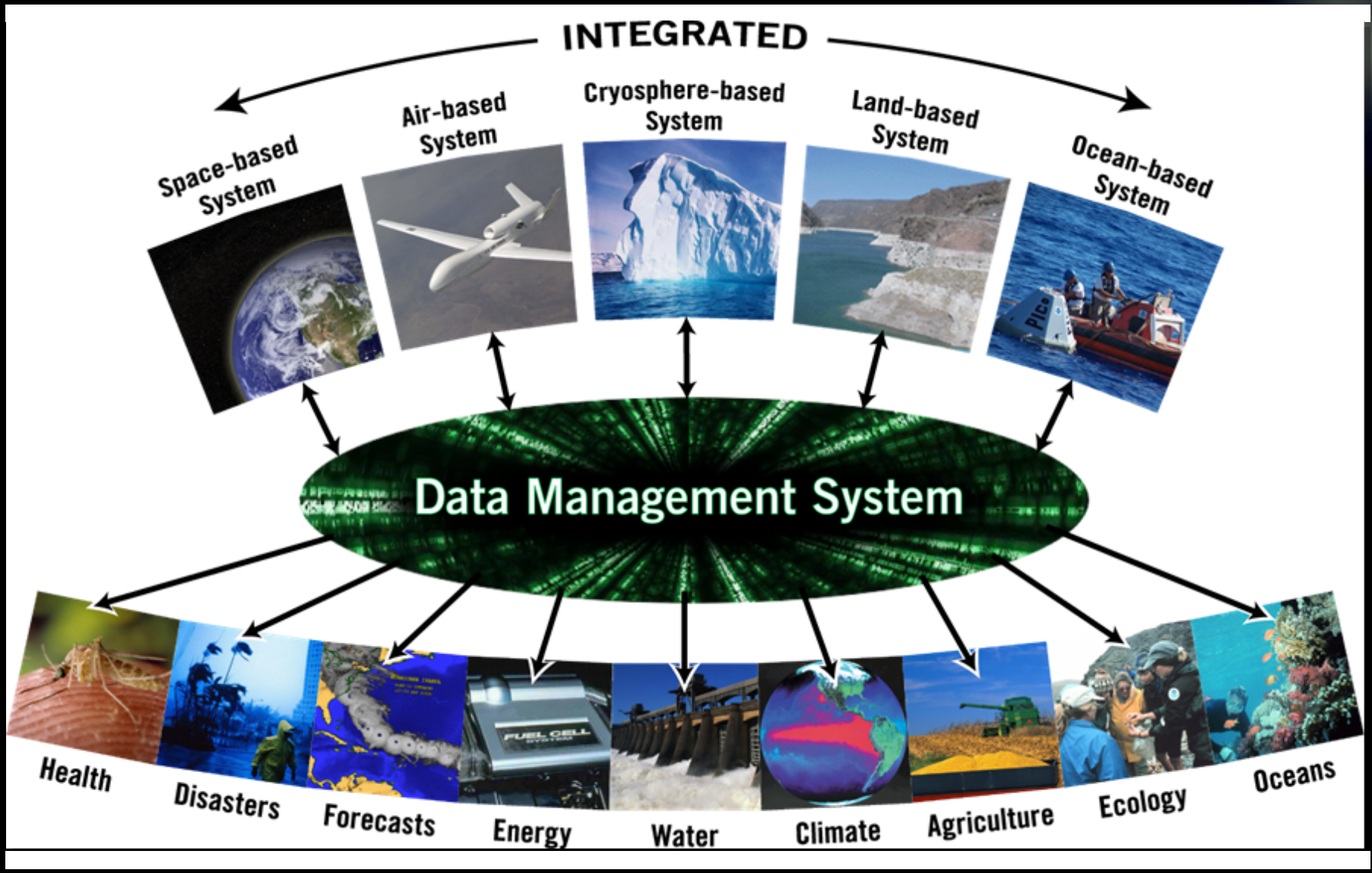
The Joint Capabilities and Opportunities of the Advanced Sounders on MetOp and NPOESS for NWP and Climate Monitoring in the GEOSS Era

ITSC-16, Session 12: Future Instruments
16th International TOVS Study Conference

Hotel do Frode and Conference Center, Angra dos Reis, Brazil
May 12, 2008

Stephen A. Mango
Chief Scientist, NPOESS Integrated Program Office
8455 Colesville Road, Suite 1450, Silver Spring, MD 20910-3320, USA
Phone (301) 713-4801; Stephen.Mango@noaa.gov

We are living in an emerging GEOSS Era …



We are looking forward to contributors to & beneficiaries from the Societal Benefits Areas

Nine Societal Benefits Areas for GEO/GEOSS

"Potential U.S. Contributions to the GEOSS"

NPOESS Will Support All GEOSS Societal Benefit Areas

Natural & Human Induced Disasters

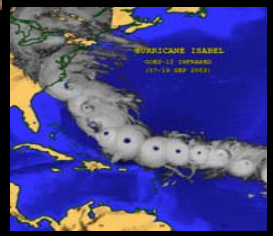
Water Resources

Ecosystems

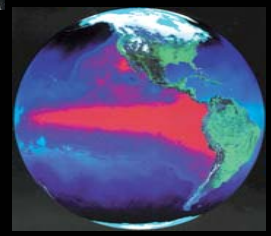
Human Health & Well-Being

Energy Resources

Sustainable Agriculture & Desertification



Weather Information, Forecasting & Warning



Climate Variability & Change

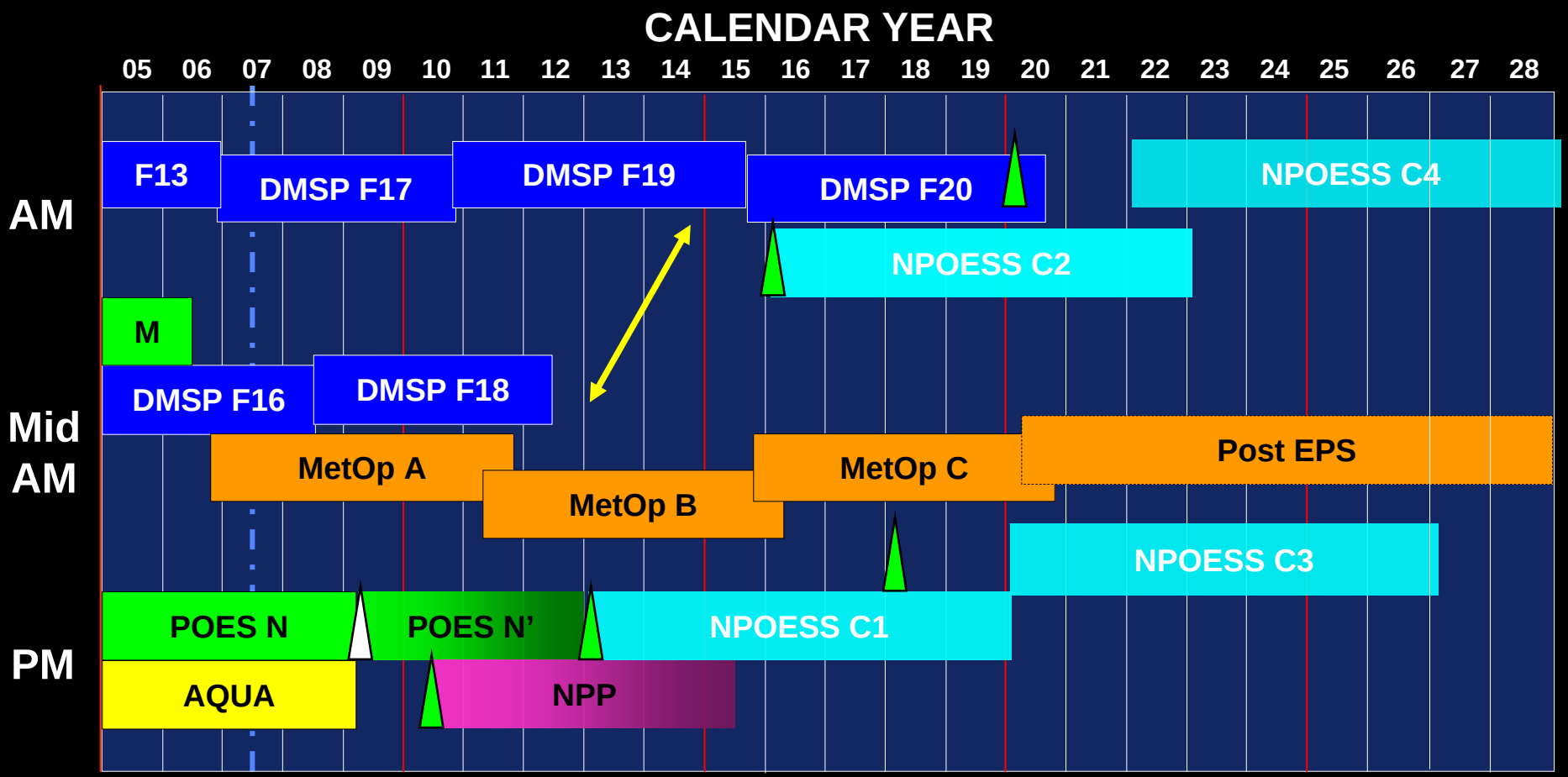
Oceans

Group on Earth Observations

US GEO focusing on Six Near-Term Opportunities

1.) Disasters
2.) Drought / National Integrated Drought Information System
3.) Land Observation
4.) Air Quality
5.) Sea Level
6.) Data Management

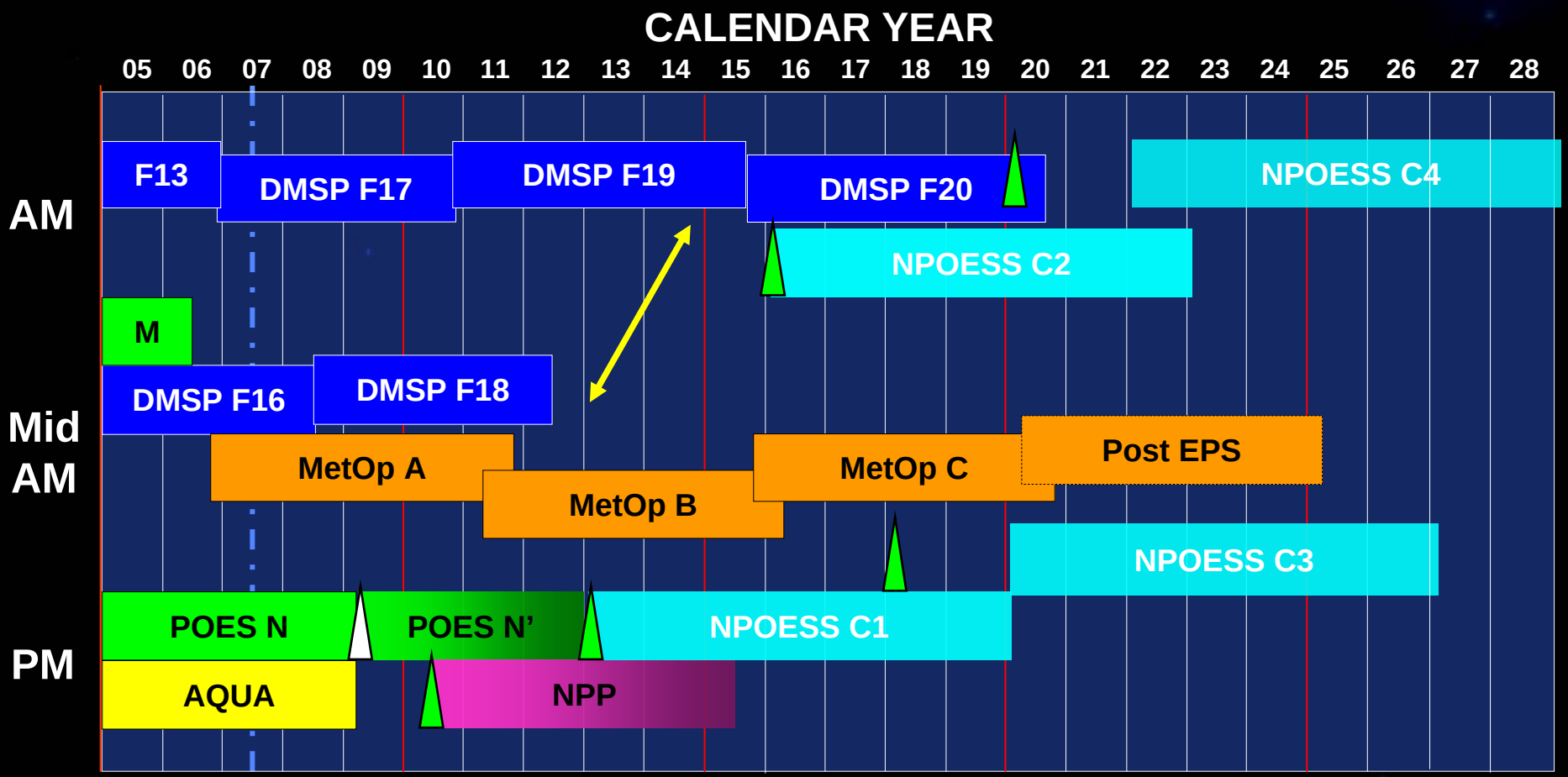
Polar-orbiting Systems : An Opportunity for Integration of Contributions



NPOESS / MetOp Span a Generation !

NPOESS & MetOp

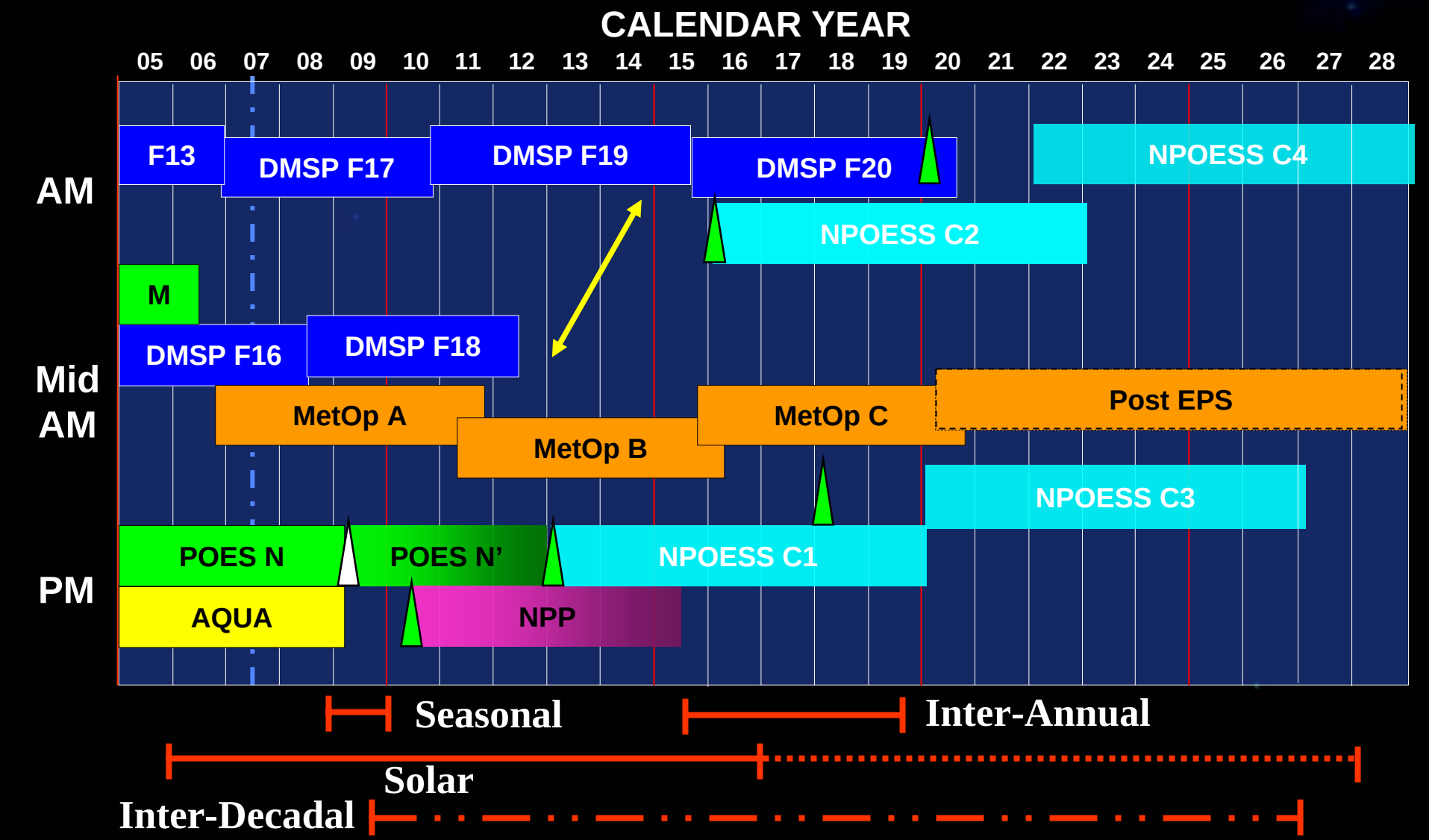
Represent an Emerging "Mini-GEOSS" System for a Generation



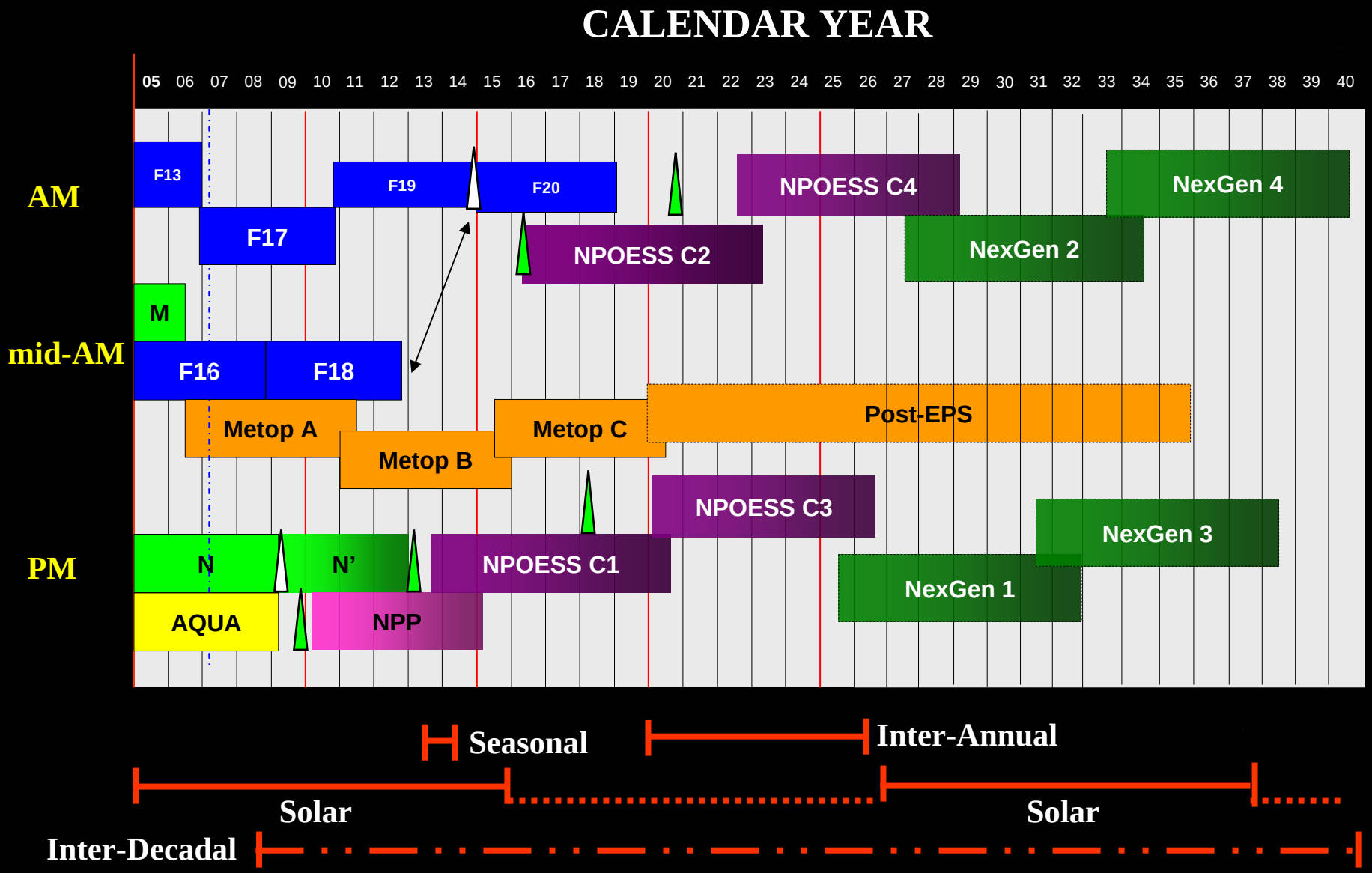
NPOESS / MetOp Span a Generation !

Several Climate & Weather [NWP] Time Scales Covered "Integrated" Polar Satellite Constellations

MetOp / NPP / NPOESS "First Generation" ~ 2010-2026 +

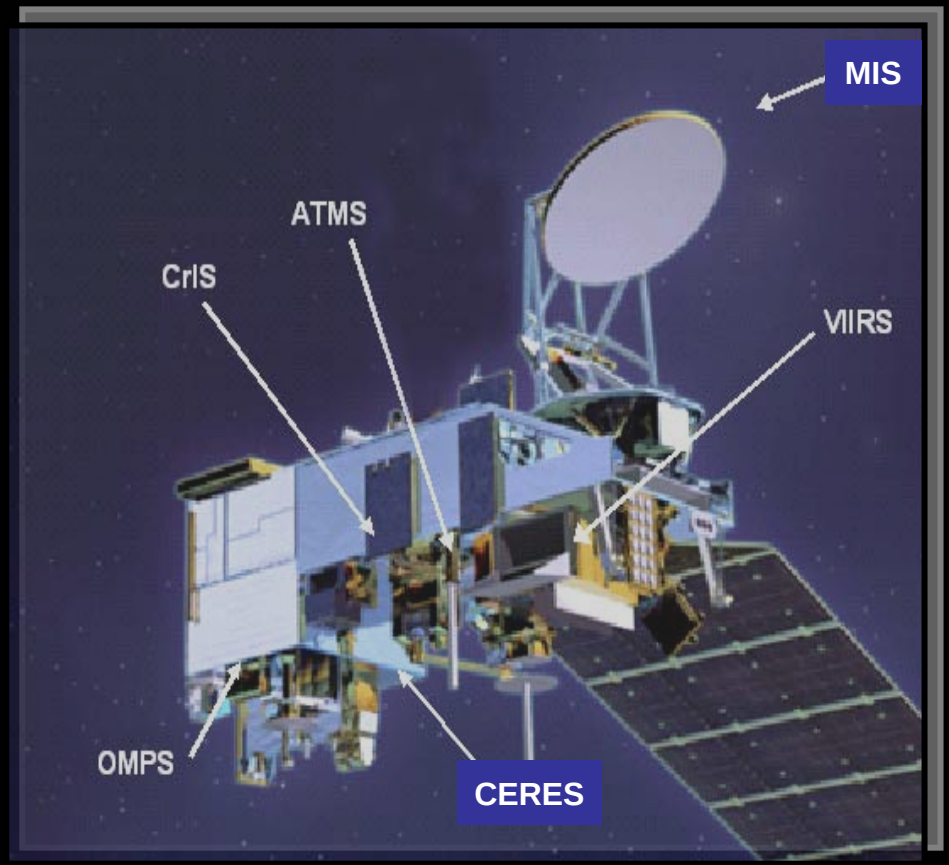


NPOESS 2nd Generation [NexGen] & European Post-EPS Notional

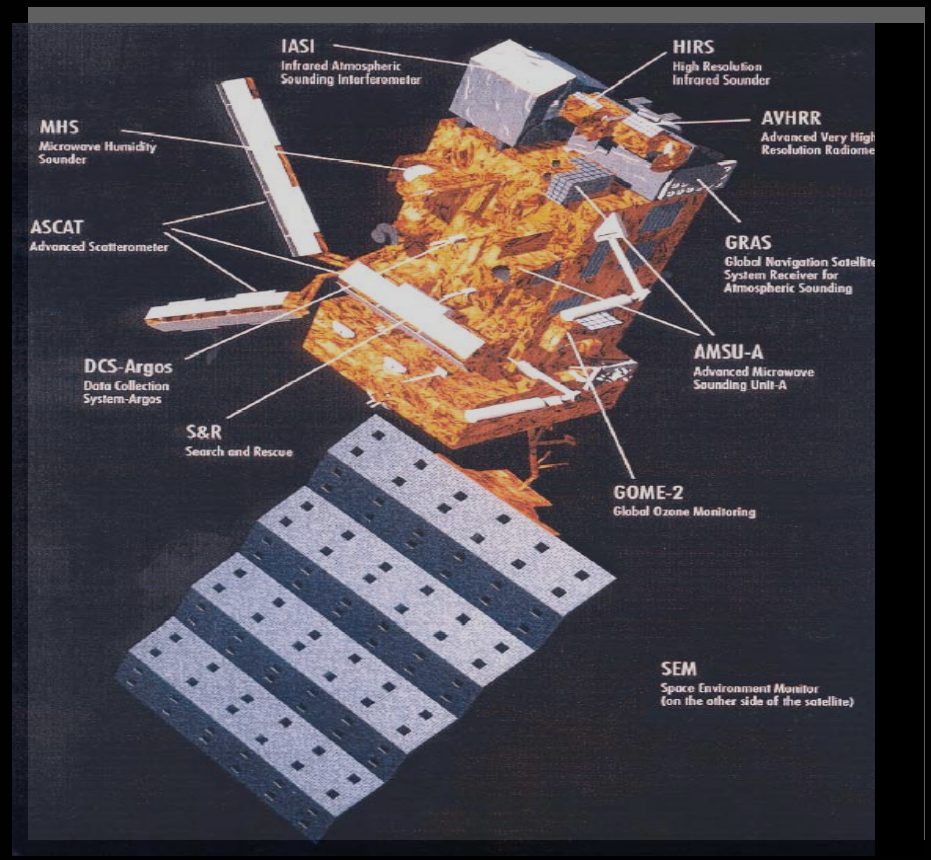


NPOESS/MetOp Sounders/Imagers/Ozone

NPOESS 1330 Satellite



MetOp 0930 (2130) Satellite

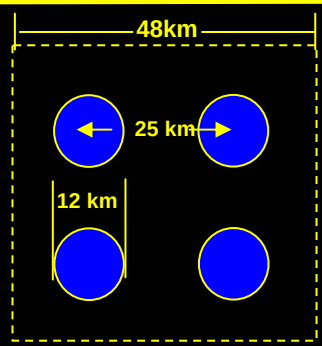


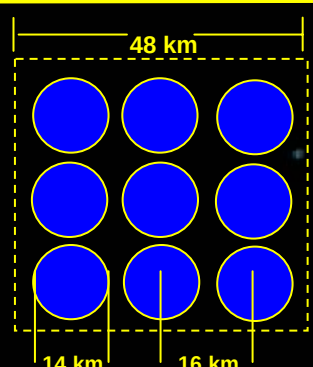
NPOESS Single Satellite Design with Common Sensor Locations and "Ring" Data Bus Allows Rapid Reconfiguration and Easy Integration

"IASI/CrIS Features - Enabling a Meaningful Global Atmospheric Sounding System for NWP & Climate"

		IASI	CrIS
# of Channels		8461	1305
Sprectral Range (cm^{-1})		650 to 770 770 to 980 1000 to 1070 1080 to 1150 1210 to 1650 2100 to 2150 2150 to 2250 2350 to 2420 2420 to 2700	650 - 1095 1210 - 1750 2155 - 2550
Sprectral Resolution (cm^{-1})		645 0.35 1210 0.35 2000 0.39 2450 0.45 2760 0.5	650-1095 <0.625 1210-1750 <1.25 2155-2550 <2.50
Sensor Parameters	Scan type	Step and dwell	Step and dwell
	Scan rate	8 sec. (30 steps earth & 3 calibration)	8 sec. (30 earth & 2 calibration)
	IFOV	3°.33 x 3°.33	3°.3 x 3°.3
	IFOC size at Nadir	12 km	14 km
	Sampling at Nadir	25 km	16 km
	Swath	± 48.3°	± 48 1/3° each side of Nadir
	Swath	± 1026 km	± 1100 km each side of Nadir
	Field of Regard (FOR)	48 km	48 km
	# IFOV's Per FOR	4 (2-by-2)	9 (3-by-3)
	Pixel/scan (FOVs x steps)	120 (4 X 30)	270 (9 X 30)

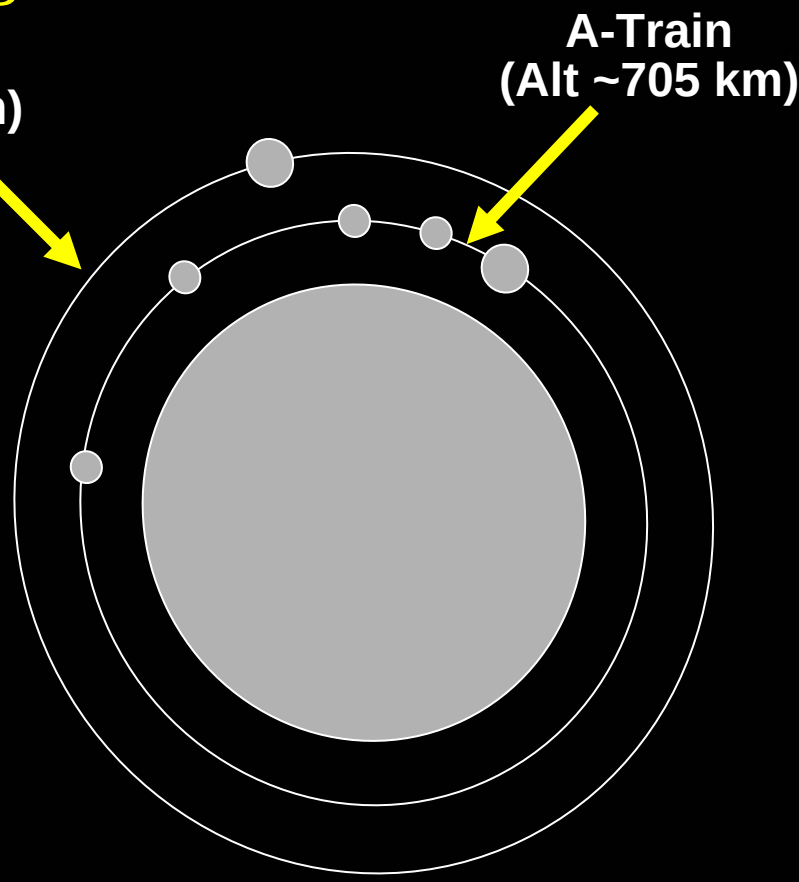
Field of Regard / Field of View





Future Opportunities: Over-flyers

"Rich" Opportunity e.g.: NPP & A-Train



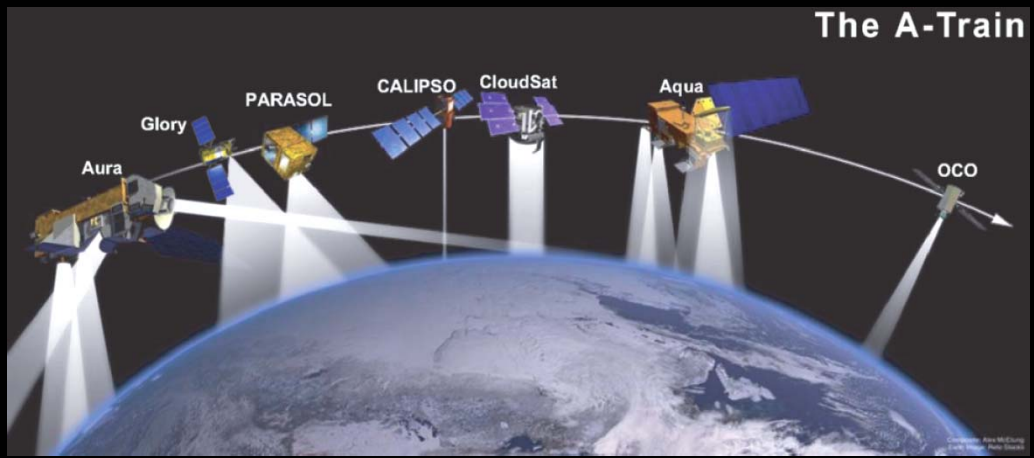
Satellites in the same orbital plane, but at different altitudes would leverage the extensive cross-comparisons & cal/val efforts of the other satellite(s) (maybe in other trains).

Synergies, Synergies, Synergies …

Adapted from S. Kidder et al.

Opportunities for Cross-Comparisons

- **Comparison of instruments on the same platform:**
  CrIS/ATMS/VIIRS; Similar approaches as AIRS/AMSU/MODIS
- **SNO method:**
  Simultaneous Nadir Overpass eliminates issues with viewing angles, atmospheric paths, observation time and location
- **Cross-Comparisons with instruments on other platforms, e.g. A-Train instruments:**
  Very useful for aerosols, clouds, temperature and water vapor



Different Ways To Carry Out Cross-Comparison In Terms of Platform(s)

Adapted from Frank Sun et al.,NGST, 2008

Opportunities
Simultaneous Nadir Overpasses (SNO)

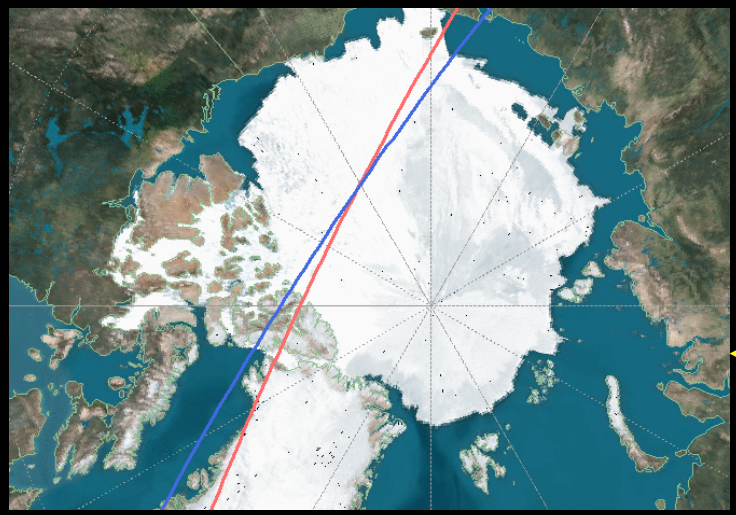
LEO vs. LEO Cross-Comparison

NOAA-18 [AM] & EOS-Terra [PM] e,g
MetOp (1,2 or 3) [AM] & NPP [PM] = similar
MetOp (1,2 or 3) [AM] & NPOESS (C1 or C3) [PM] = similar
NPOESS (C2 or C4) [early AM] & NPOESS (C1 or C3) {mid AM]

GEO vs. LEO Cross-Comparison

EOS/Hyperion & GOES-R e,g
Any LEO & Any GEO = similar

LEO vs. LEO Inter-Calibration



MetOp (1,2 or 3) [AM] & EOS/Hyperion e.g.
MetOp (1,2 or 3) [AM] & NPP [PM] = similar
MetOp (1,2 or 3) [AM] & NPOESS (C1 or C3) [PM] = similar
NPOESS (C2 or C4) [early AM] & NPOESS (C1 or C3) {mid AM]

Orbit Trajectories courtesy of Changyong Cao and Mitch Goldberg, NOAA/NESDIS

What Cross-Comparisons Can Do

- To provide early on orbit quick look of NPP/MetOp/NPOESS instruments & algorithms performance by comparing with other well understood/calibrated instruments & validated products.
- Independently and **periodically calibrate**, validate, & monitor NPP/Metop/NPOESS instruments, algorithm performance throughout the mission/instrument lifetimes.
- Independent evaluation for the transfer of trends from EOS, MetOp, through NPP, to NPOESS
- MetOp/NPP/NPOESS to be an important part of WMO Global Space-based Inter-Calibration System (GSICS)

NPP over-fly of A-Train, MetOp over-fly of A-Train, NPOESS C1 over-fly of NPP, providing unique opportunities for cross comparison of Environmental Satellite Data Records: from EOS, MetOp through NPP, to NPOESS

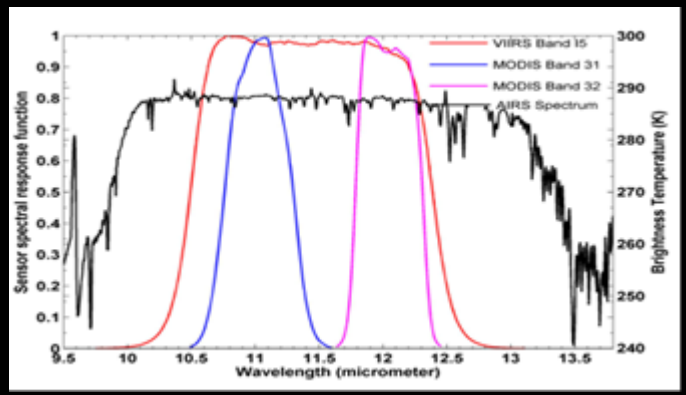
Adapted from Frank Sun et al.,NGST, 2008

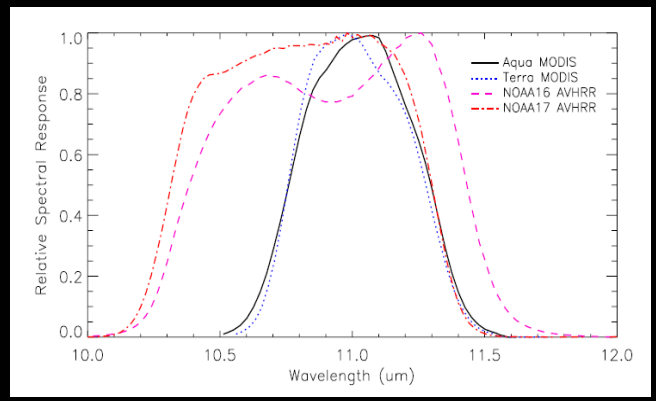
Overview of Cross-Comparisons

SDR Cross-Comparison (L1B, SDR data)

[Major emphasis by IPO]

Issues: location, time, scan angle, fp differences, & band & band characterization differences





EDR Cross-Comparison (L2, EDR products)

[Emphasis by IPO for selected EDRs]

Issues: resolution, algorithm differences (CTP, for example); instrument signatures

CDR Cross-Comparison (L3 gridded data, higher level products)

[To be performed by other groups/agencies, e.g. NCEP/NASA/ECMWF]

Three Levels of Cross-Comparison in Terms of Data Products

3 Levels of Cross-Comparison for Sounding & Imaging Products

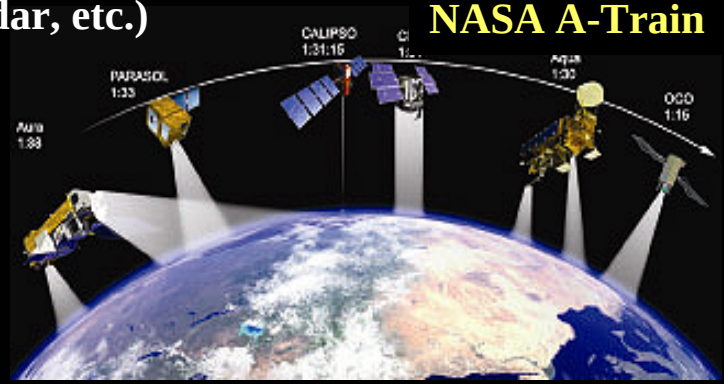
Adapted from Frank Sun et al.,NGST, 2008

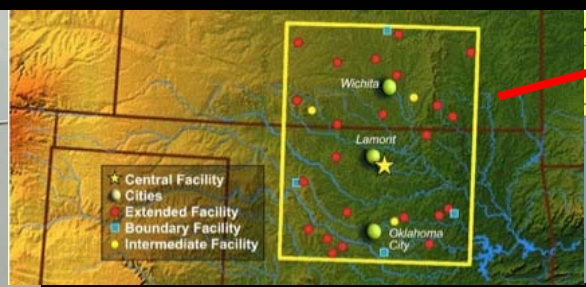
Penultimate Sounding/Imaging Opportunity for Fly-over & Fly-under Cross-Comparisons

JAIVEx (Joint Airborne IASI Validation Experiment)

International collaboration to validate radiance and geophysical products obtained by the Infrared Atmospheric Sounding Interferometer (IASI) aboard the MetOp satellite

- **Location/dates**
  - Ellington Field (EFD), Houston, TX, 14 Apr – 4 May, 2007
- **Aircraft**
  - NASA WB-57 (NAST-I, NAST-M, S-HIS)
  - UK FAAM BAe146-301 (ARIES, MARSS, SWS; dropsondes; in-situ cloud phys. & trace species; etc.)
- **Ground-sites**
  - DOE ARM CART ground site (radiosondes, Raman Lidar, etc.)
- **Satellites**
  - Metop (IASI, AMSU, MHS, AVHRR, HIRS, ASCAT)
  - A-train (Aqua AIRS, AMSU, HSB, Modis; Aura TES; CloudSat; and Calipso)
- **Participants**
  - US : IPO, NASA, UW, MIT, MIT-LL, NOAA,
  - Europe : UKMO, EUMETSAT, ECMWF, …





Adapted from US NAST Team – Smith et al. and UK Met Office Team – Taylor et al.

" Enabling a Meaningful Global Atmospheric & Ozone Sounding System for NWP & Climate "

[CrIS/IASI & ATMS/AMSU-MHS & OMPS/GOME-2 & MIS* & GRAS]

Timeliness	MetOp IASI/HIRS/AMSU/MHS & GOME-2 & GRAS	NPOESS CrIS/ATMS & OMPS & MIS
Latency Requirement (Minutes)	180	156 Threshold 15 Objective
Latency Performance (Minutes)	104 – 135	28
Revisit Time (Hours)	12 (Any One Satellite) 6 (MetOp with 2 NPOESS)	6 (Two OZONE Satellites)[1] 6 (Two* Sounder Satellites)[2] *Incl. 1 NPOESS & 1 MetOp

[1] 6 hour revisit for two phased satellites (OMPS on 1330 NPOESS & GOME-2 on METOP 2130)

[2] 6 hour revisit for three phased satellites (CrIS/ATMS/CMIS on NPOESS 1330 & IASI/AMSU/MHS/GOME-2/GRAS on 2130 MetOp; also MIS on NPOESS 2130 [C2C3,C4])

CrIS + ATMS = CrIMSS Will Allow Several Atmospheric/Surface Products to be Retrieved for NWP & Climate

- The **CrIMSS product algorithm**, developed by **AER** (SDR-to-EDR) and **BOMEM** (RDR-to-SDR), is an iterative physical retrieval algorithm to retrieve atmospheric temperature, moisture and pressure profile EDRs from the **Cross-track Infrared and Microwave Sounder Suite (CrIMSS)** measurements

- **Retrieved Parameters will include:**
  - **Temperature Profile** (reconstructed from 20 temperature EOFs)
  - **Moisture Profile** (reconstructed from 10 moisture EOFs)
  - **Pressure Profile**
  - **Surface Temperature**
  - **Surface IR Emissivity** (at 12 frequency hinge points)
  - **Surface IR Reflectance** (at 12 frequency hinge points)
  - **Ozone Total Column**
  - **Surface MW Emissivity** (reconstructed from 5 MW emissivity EOFs)
  - **MW Cloud Top Pressure** and **Cloud Liquid Water Path**
- **Additional possible Products [GHG / Trace Gases] (special cases)**
  CO, N_20, CH_4, CO_2
  [NPOESS Users' IORD Requirements, Pre-Planned Product Improvements]

Trace/Greenhouse Gases (CO, CH_4, CO_2)

NPOESS Users' P^{3}I* IORD EDR Requirements

CH_4 Column

CH_4 (Methane)	Objectives
Vert Coverage	Total Column
Horizontal Resolution	100 km
Mapping Uncertainty	25 km
Meas Range	40-80 μmoles/cm^2
Meas Precision	1%
Meas Accuracy	5%
Latency	15 min
Refresh	24 hrs

CO Column

CO (Carbon Monoxide)	Objectives
Vert Coverage	Total Column
Horizontal Resolution	100 km
Mapping Uncertainty	25 km
Meas Range	0-7 μmoles/cm^2
Meas Precision	3%
Meas Accuracy	+/-5%
Latency	15 min
Refresh	24 hrs

CO_2 Column

CO_2 (Carbon Dioxide)	Objectives
Vert Coverage	Total Column
Horizontal Resolution	100 km
Mapping Uncertainty	25 km
Meas Range	11,000-15,000 μmoles/cm^2
Meas Precision	15-20 μmoles/cm^2
Meas Accuracy	TBD
Latency	15 min
Refresh	24 hrs

•P^{3}I = Pre-Planned Product Improvement Requirements in NPOESS Users' Integrated Operational Requirements Document [IORD II]

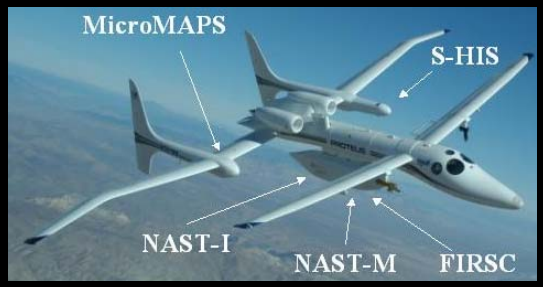
All three trace gas EDRs require :

- Total column measurement
- 100 km horizontal resolution
- No Thresholds, only Objectives in IORD

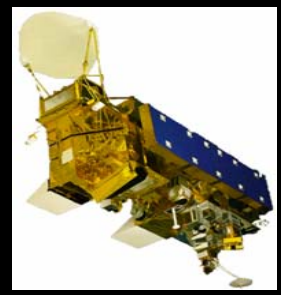
Langley Research Center

Possible Future CrIS Capability e.g.
Carbon Monoxide [CO] Trace Gas Profiling & Column Density

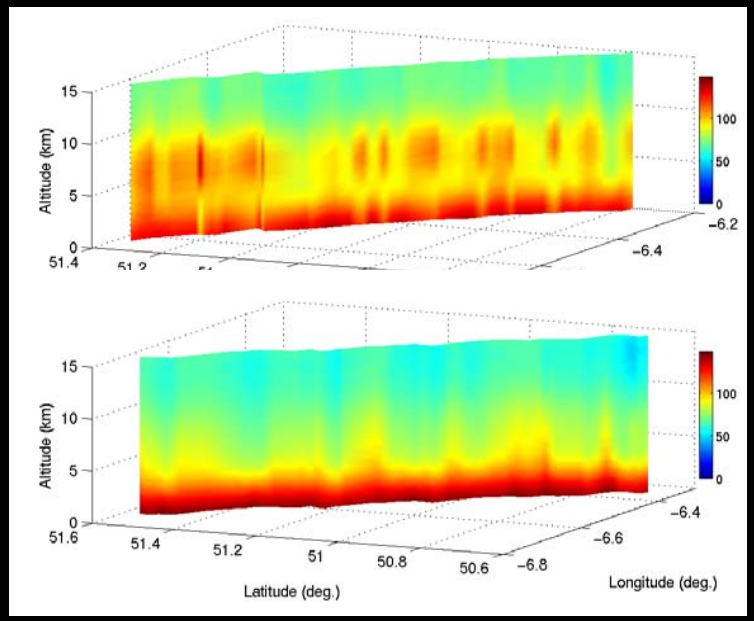
Airborne NAST- I
EAQUATE AIRS Validation Campaign
14 and 18 September 2004

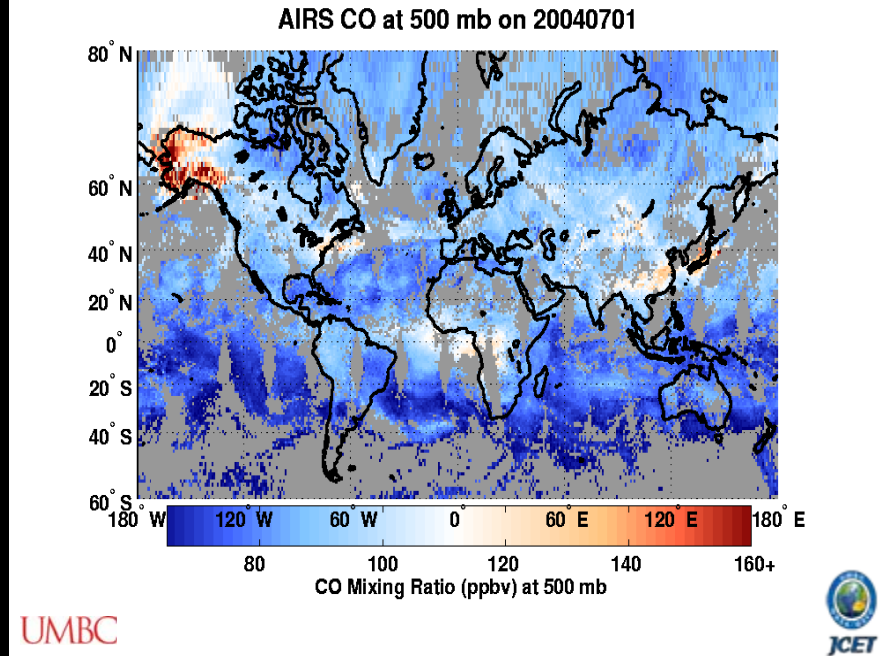


Spaceborne AQUA AIRS
CO Daily Averages - Month of July 2004
At Single Height Level - 500 mb



NAST- I CO Vertical Cross Sections
CO [carbon monoxide] in ppbv





Muito Obrigado para sua atenção !