Forthcoming changes in the Global Satellite Observing Systems

Mitch Goldberg, NOAA

Outline

- Overview of CGMS and CEOS.
- Overview of the key satellite observations for NWP
- Discuss satellite agencies plans for these key observations
- Short overview emerging observations or technology which we need to pay attention to.
- Summary

COORDINATION GROUP FOR METEOROLOGICAL SATELLITES (CGMS)

CGMS provides an international forum for the exchange of technical information on geostationary and polar orbiting meteorological satellite systems.

The Coordination Group for Meteorological Satellites (CGMS) came into being on 19 September 1972, when representatives of the European Space Research Organisation (since 1975 called the European Space Agency, ESA), Japan, the United States of America, Observers from the World Meteorological Organisation (WMO) and the Joint Planning Staff for the Global Atmosphere Research Programme met in Washington to discuss questions of compatibility among geostationary meteorological satellites. EUMETSAT has run the Secretariat since 1987.

CGMS provides an international forum for the exchange of technical information on geostationary and polar orbiting meteorological satellite systems. It consists of **15 member organisations** and **six observers**. For full details of CGMS objectives, activities, membership, **CGMS publications** and meetings please visit the dedicated **CGMS website**.

CGMS is behind a number of initiatives, including Global Space-based Inter-Calibration System (GSICS), the **Sustained, Coordinated Processing of Environmental Satellite Data for Climate Monitoring** (SCOPE-CM) and **Virtual Laboratory**. More information is available about these initiatives on the CGMS website.

As the Secretariat, EUMETSAT is responsible for organising the annual **CGMS Plenary meeting** with the support of the local host, which is a CGMS Member designated on a rotating basis. Between sessions of the annual CGMS Plenary meetings, the Secretariat is also in charge of facilitating the communication between CGMS Members and of ensuring that actions agreed during CGMS Plenary meetings are fulfilled and the publication of the **CGMS meeting report**.

The CGMS Secretariat represents CGMS Members in a number of International bodies such as the **Committee on Earth Observation Satellites** (CEOS) and its related Earth Observation International Coordination Working Group (EO-ICWG), **Group on Earth Observation** (GEO), and the **Space Frequency Coordination Group** (SFCG).

GLOBAL SPACE-BASED INTER-CALIBRATION SYSTEM (GSICS)

The **Global Space-based Inter-Calibration System** (GSICS) is an initiative of CGMS and WMO, which aims to ensure consistent calibration and inter-calibration of operational meteorological satellite instruments.

Members:

CMA
CNES
CNSA
ESA
EUMETSAT
IMD
IOC/UNESCO
JAXA
JMA
KMA
NASA
ROSCOSMOS
ROSHYRDOMET
WMO

Observers:
CSA
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CGMS

The Coordination Group
for Meteorological Satellites

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There are four CGMS Working Groups within the scope of CGMS: WGI on global issues on satellite systems and telecommunication coordination; WGII on satellite data and products; WGIII on operational continuity and contingency planning; and WGIV on global data dissemination.

In addition, there are four Working Groups interacting with CGMS: The International ATOVS Working Group - ITWG; the International Precipitation Working Group - IPWG; the International Winds Working Group - IWWG; and the International Radio Occultation Working Group - IROWG. The last three Working Groups originate from CGMS WGII and plenary sessions.

- Working group I (WGI): Global issues on satellite systems and telecommunication coordination [+]
- Working group II (WGII): Satellite data and products [+]
- Working group III (WGIII): Operational Continuity and Contingency Planning [+]
- Working Group IV (WGIV): Global data dissemination [+]
- International TOVS Working Group: ITWG [+]
- International Precipitation Working Group: IPWG [+]
- International Radio Occultation Working Group: IROWG [+]
- International Winds Working Group: IWWG [+]

- Working Groups
  - Advanced Sounders
  - NWP
  - Climate
  - Radiative Transfer
  - Products and Software
  - International and Future Systems
- Technical Subgroups
  - Direct broadcast packages/ RARS
  - RTTOV
  - CRTM

The Coordination Group
for Meteorological Satellites

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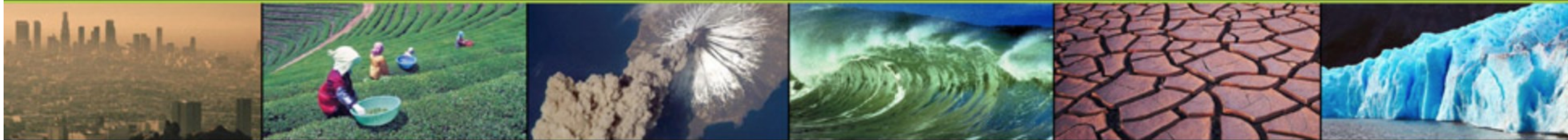
There are among other three major initiatives resulting from CGMS:

- Global Space-based Inter-Calibration System - GSICS
- Sustained, Co-Ordinated Processing of Environmental Satellite Data for Climate Monitoring
- Virtual Laboratory - Vlab
- CEOS-CGMS JOINT WG ON CLIMATE

CEOS Committee on Earth Observation Satellites



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Mission: CEOS ensures international coordination of civil space-based Earth observation programs and promotes exchange of data to optimize societal benefit and inform decision making for securing a prosperous and sustainable future for humankind.

Explore this website to learn more about how CEOS is optimizing the societal benefit of space-based Earth observation. CEOS agencies currently operate 107 missions and 286 instruments. To learn more about those missions, instruments, and upcoming launches, visit the EO Handbook.

For additional information about CEOS, please contact Kerry Sawyer (CEOS Executive Officer).

SIT Technical Workshop: September 17-18, 2014 Montpellier, France

The SIT Technical Workshop will take place on 17-18 September, 2014 in Montpellier, France (Hosted by CNES). Meeting materials are available at www.ceos.org/sitworkshop2014.

Recent Achievements

	July, 2014 - NASA celebrates the successful launch of OCO-2: the Orbiting Carbon Observatory. OCO-2 is NASA's first mission dedicated to studying atmospheric carbon dioxide, the leading human-produced greenhouse gas driving changes in Earth's climate.
	**May, 2014** - Congratulations to JAXA on the successful launch of the Advanced Land Observing Satellite-2 (ALOS-2/DAICHI-2)! The state of the art L-band Synthetic Aperture Radar (PALSAR-2) on board will support Earth observations related to disasters, agriculture, carbon, and more.
	**March, 2014** - Congratulations to the European Space Agency (ESA) and European Commission (EC) on the successful launch of Sentinel-1A, "the first in a fleet of ESA satellites poised to deliver the wealth of data and imagery that are central to Europe's Copernicus programme." View videos of Sentinel-1A's liftoff and separation in space.

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CEOS Publications

2015 Deliverables in Support of the GEOSS
December 2013

Montreal Statement
November 2013

CEOS Newsletter No. 42
March 2014

CEOS Videos

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Portals

- CEOS International Directory Network (IDN)
- Land Surface Imaging (LSI)
- Atmospheric Composition (AC)
- Climate Diagnostics
- Calibration / Validation
- Forest Carbon Tracking
- CEOS Water Portal

Special Teams

Strategy for addressing key satellite data

- Begin with
  - WIGOS 5th Workshop of the Impact of Various Observing Systems on NWP (Sedona Report).
  - UKMO impact report: Impact of Metop and other satellite data within the Met Office global NWP system using a forecast adjoint-based sensitivity method- Feb 2012, tech repot #562 and MWR October 2013 paper
  - Recall key observation types for NWP
  - Compare with what space agencies are planning to provide continuity and enhancements to these observing types.
    - Make use of the WMO OSCAR database
  - Time scale between now and 2030.

Sedona Report

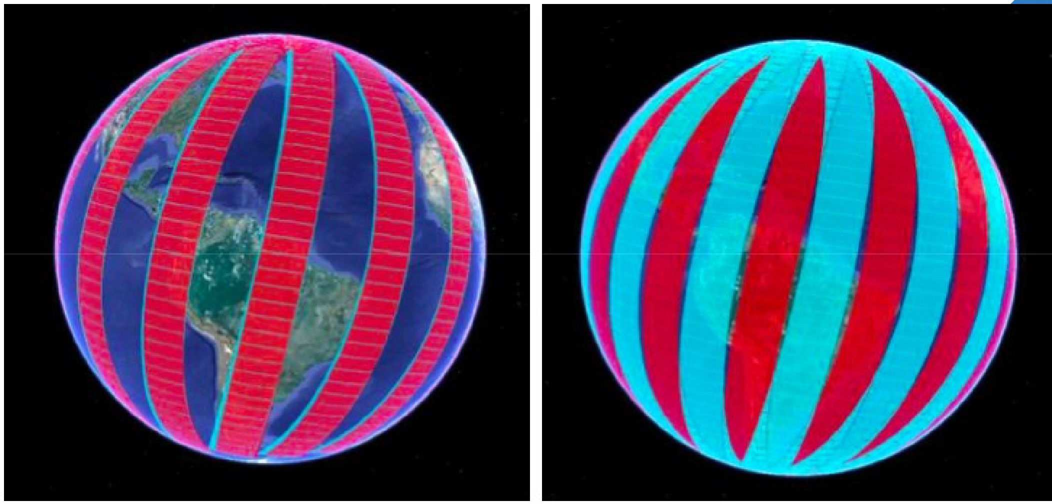
- Observations contributing to the largest reduction of forecast errors are those observations with vertical information (temperature, water vapor).
- The single instrument with the largest impact is hyperspectral IR
- Microwave dominates because of the number of satellites and ability to view thru low water content clouds.
- However, there is now no single, dominating satellite sensor.
- GPSRO shows good impact, and largest impact per observation
- Atmospheric Motion Vector Winds and Scatterometers are single level data and have modest impacts
- Concerns about the declining number of observations into the future – mostly due to the replacement of 2 year life satellites with 7 years (e.g. NOAA-15 vs. JPSS-1) and due to de-orbiting requirements to reduce space debris.
- Concerns about decline of GPSRO with COSMIC end of life…
- Depending on the future plans and implementations of satellite agencies, a single sensor failure may begin to have larger ripples in impacting forecast skill.
- High quality data is critical
- Open and free access of data in near real-time is also critical.

Optimization of the observing system needs to include analysis of orbital parameters

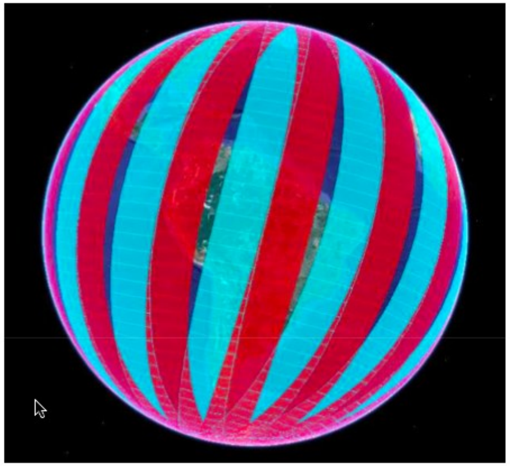
- GCOM-C1 (10:30)and Sentinal 3A (10:00)

- With minor adjustments to the planned orbit of GCOM-C1 (4 km altitude, <0.1 deg inclination, 2 min ECT), the constellation can maximize the daily coverage potential and remove the oscillations in relative spacing between adjacent swaths that create periods of poor coverage.

From Brian Killough (NASA)

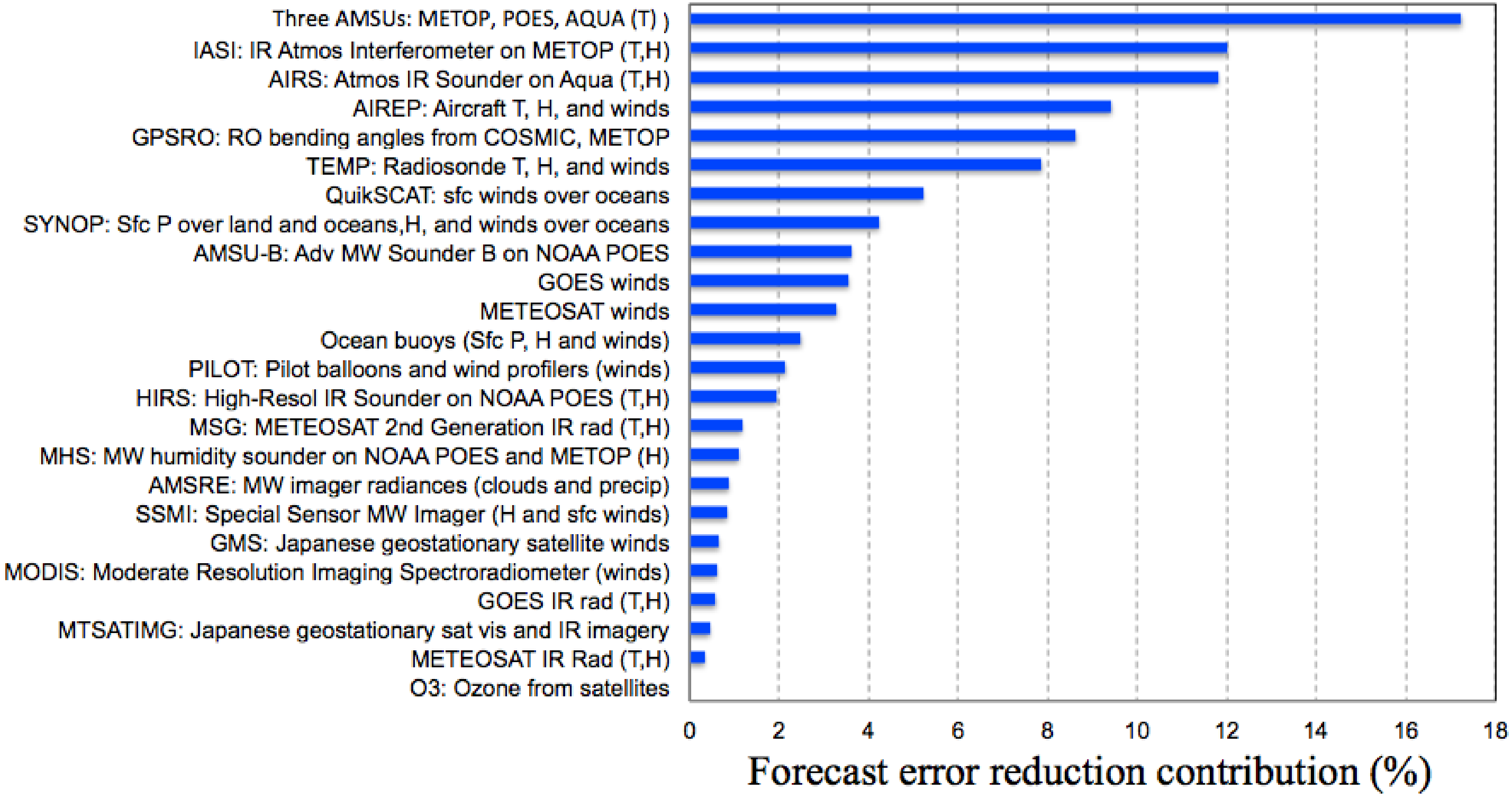


Coverage of GCOM-C and ESA Sentinel 3A over 3 month range



Improved coverage maintained with different orbital parameters

From ECMWF from ~2009



Source: Healy and Cardinali

The Impact of MetOp and Other Satellite Data within the Met Office Global NWP System Using an Adjoint-Based Sensitivity Method

SANGWON JOO
Korea Meteorological Administration, Seoul, South Korea
JOHN EYRE AND RICHARD MARRIOTT
2013

TABLE 1. Satellite observation types used in this study and affected NWP variables. See the appendix for explanations of acronyms.

Observation type	Satellite	NWP variables
AMSU-A/MHS radiances	*NOAA-15, -17, -18, -19* + *MetOp-A*	Temperature, humidity
HIRS clear-sky radiances	*NOAA-17* and *-19* + *MetOp-A*	Temperature, humidity
IASI and AIRS clear + cloudy radiances	*MetOp-A* + *Aqua*	Temperature, humidity
SSMIS radiances	DMSP (*F-16*)	Temperature, humidity
GEO imager clear IR radiances	MSG (*Meteosat-9*), GOES	Humidity
GPSRO bending angles	Five COSMIC satellites, *MetOp-A*/GRAS, GRACE	Temperature, humidity
AMVs: GEO	*Meteosat-7*, MSG (*Meteosat-9*), MTSAT, *GOES-11* and *-13*	Wind
SEVIRI clear-sky radiances	MSG (*Meteosat-9*)	Temperature, humidity
AMVs: MODIS and AVHRR	*Aqua*, *Terra*, NOAA	Wind
Scatterometer sea surface wind	*MetOp-A*/ASCAT	Surface wind
MW imager sea surface wind	*Coriolis*/WindSat	Surface wind

"Note that several other satellite data types are also used to initialize other NWP variables—sea surface temperature, sea ice, snow cover, and soil moisture—but not as part of the 4DVAR process. Consequently, the impact of observations important for their analysis will not be measured by the FSO method"

"The impacts per sounding of the hyperspectral IR sounders, MetOp-A/IASI and Aqua/AIRS, are larger than those of the microwave sounders"

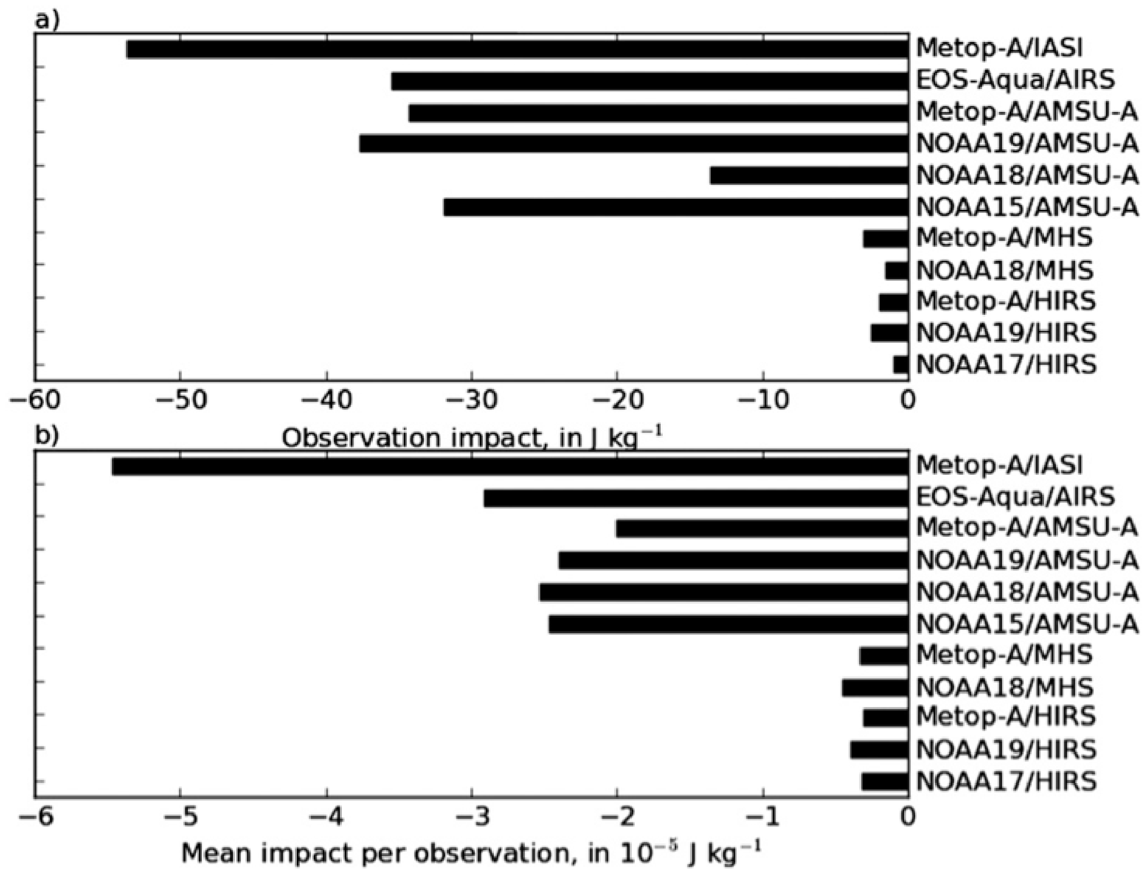


FIG. 5. (a) Observation impact and (b) mean impact per observation of the instruments using MWS and IRS techniques.

Breakdown of the impacts

(note FSO computed from surface to 150 hPa)

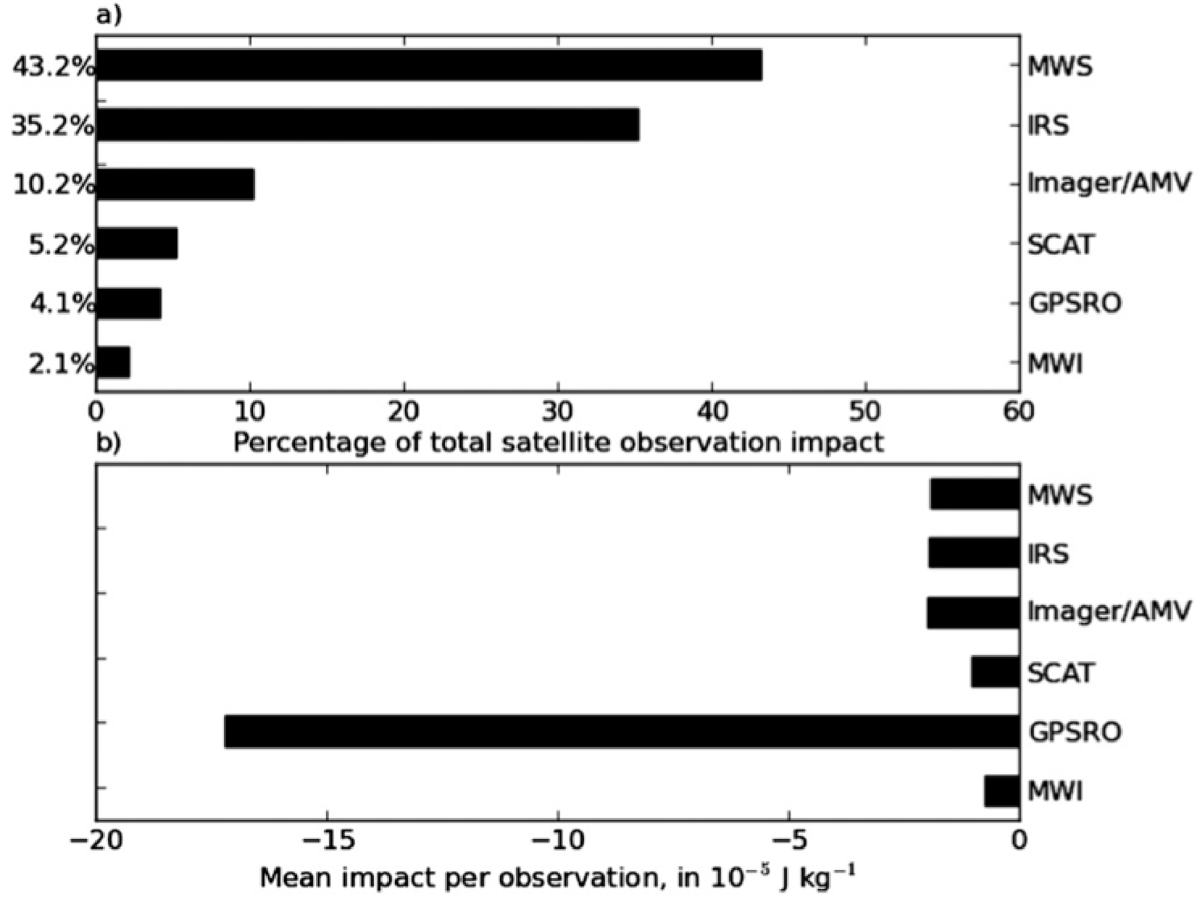
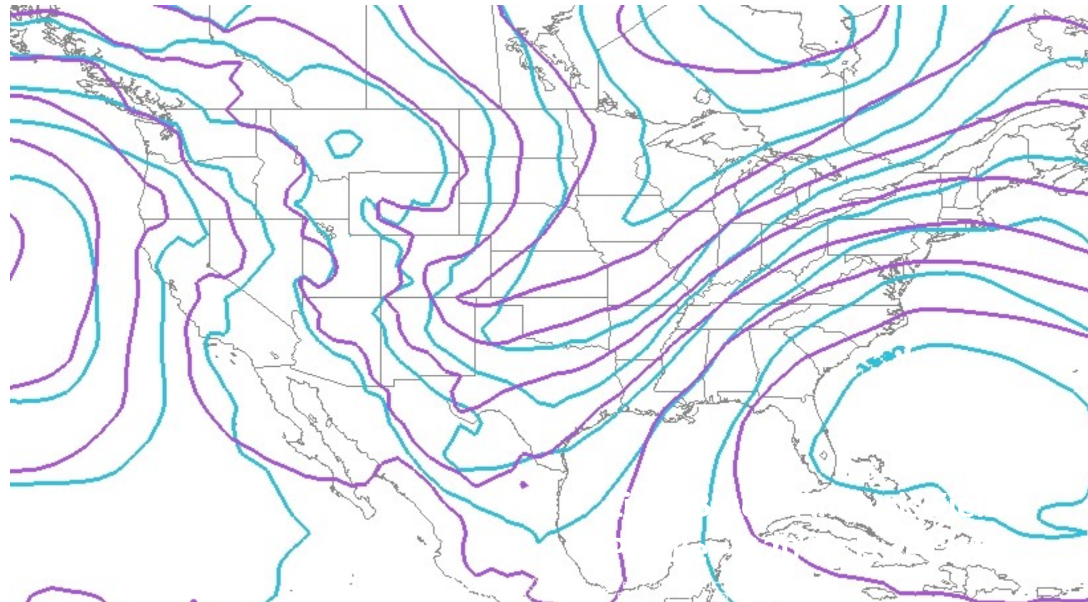


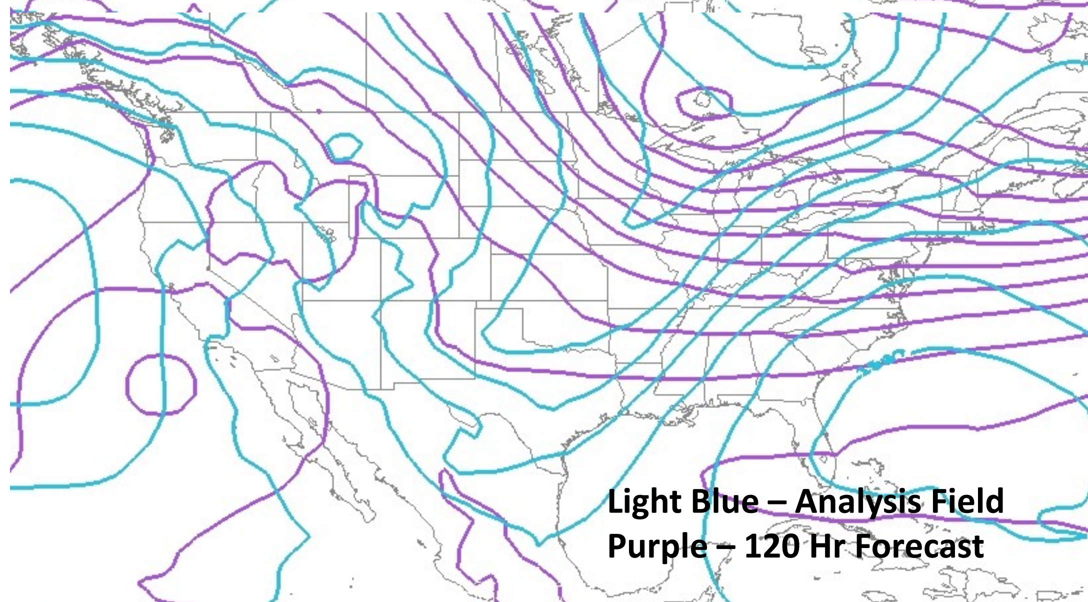
FIG. 4. Comparison of the impacts from observations of each satellite observing technique as described by the technique column of Table 2. The (a) observation impact and (b) mean impact per observation.

Analysis Field vs 120 Hr GFS Forecast 850 hPa
29 January 2013

120 Hour Forecast with ALL Satellite Data



120 Hour Forecast with Conventional plus GPSRO



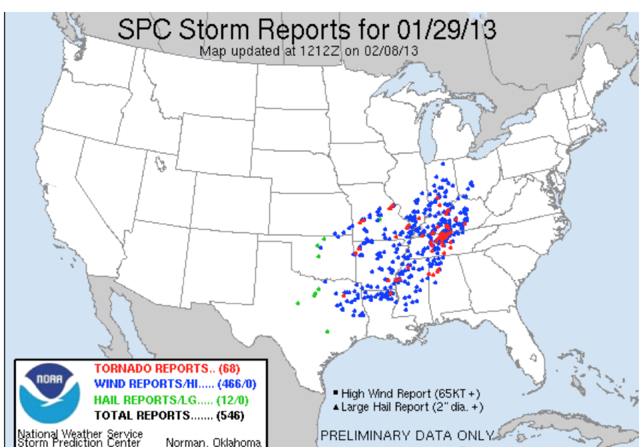


TABLE 2. Detailed observations for each subset compared.

Observation	Subtype	Platform	Technique
MetOp-A/IASI	MetOp	*MetOp-A*	IRS
MetOp-A/AMSU-A	MetOp	*MetOp-A*	MWS
MetOp-A/MHS	MetOp	*MetOp-A*	MWS
MetOp-A/HIRS	MetOp	*MetOp-A*	IRS
MetOp-A/ASCAT	MetOp	*MetOp-A*	SCAT
MetOp-A/GRAS	MetOp	*MetOp-A*	GPSRO
NOAA-15/AMSU-A	NOAA	*NOAA-15*	MWS
NOAA-15/AVHRR	NOAA	*NOAA-15*	Imager/AMV
NOAA-16/AVHRR	NOAA	*NOAA-16*	Imager/AMV
NOAA-17/HIRS	NOAA	*NOAA-17*	IRS
NOAA-17/AVHRR	NOAA	*NOAA-17*	Imager/AMV
NOAA-18/AMSU-A	NOAA	*NOAA-18*	MWS
NOAA-18/MHS	NOAA	*NOAA-18*	MWS
NOAA-18/AVHRR	NOAA	*NOAA-18*	Imager/AMV
NOAA-19/HIRS	NOAA	*NOAA-19*	IRS
NOAA-19/AMSU-A	NOAA	*NOAA-19*	MWS
NOAA-19/AVHRR	NOAA	*NOAA-19*	Imager/AMV
EOS *Aqua*/AIRS	Other LEO	*Aqua*	IRS
EOS *Aqua*/MODIS	Other LEO	*Aqua*	Imager/AMV
EOS *Terra*/MODIS	Other LEO	*Terra*	Imager/AMV
DMSP *F-16*/SSMIS	Other LEO	*DMSP F-16*	MWI
ERS-2/AMI	Other LEO	*ERS-2*	SCAT
Coriolis/WindSat	Other LEO	Coriolis	MWI
GOES/AMVs	GEO	GOES	Imager/AMV
MTSAT/AMVs	GEO	MTSAT	Imager/AMV
Meteosat/AMVs	GEO	Meteosat	Imager/AMV
Meteosat/SEVIRI CLR	GEO	Meteosat	Imager/AMV
COSMIC	Other RO	Other RO	GPSRO
GRACE-A	Other RO	Other RO	GPSRO
AMDAR	Aircraft	N/A	N/A
AIREP	Aircraft	N/A	N/A
PILOT	Sonde	N/A	N/A
TEMP	Sonde	N/A	N/A
Dropsonde	Sonde	N/A	N/A
Wind profiler	Sonde	N/A	N/A
SYNOP	Land surface	N/A	N/A
BOGUS	Land surface	N/A	N/A
TCBOGUS	Sea surface	N/A	N/A
BUOY	Sea surface	N/A	N/A
SHIP	Sea surface	N/A	N/A

Space-based 64%
(note FSO computed from surface to 150 hPa)

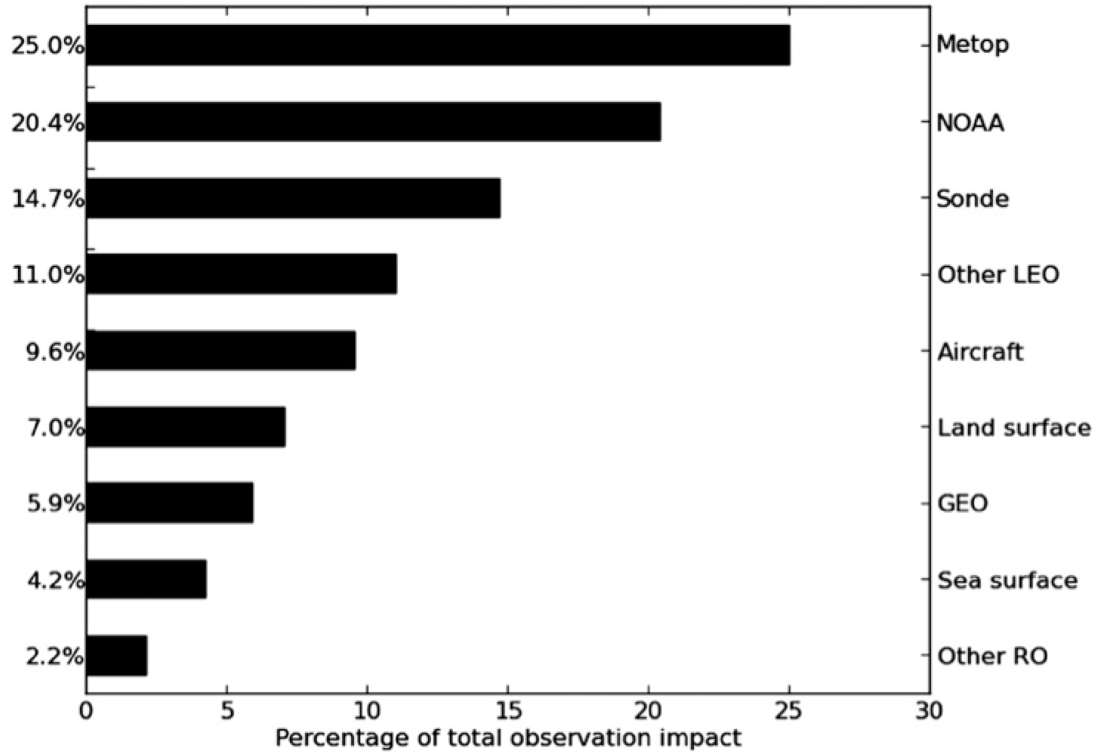
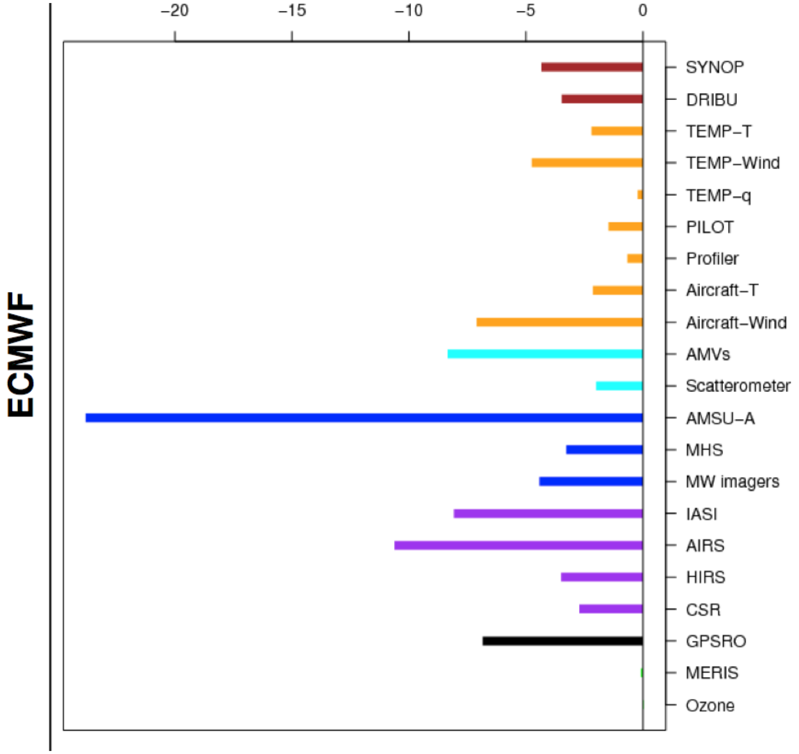
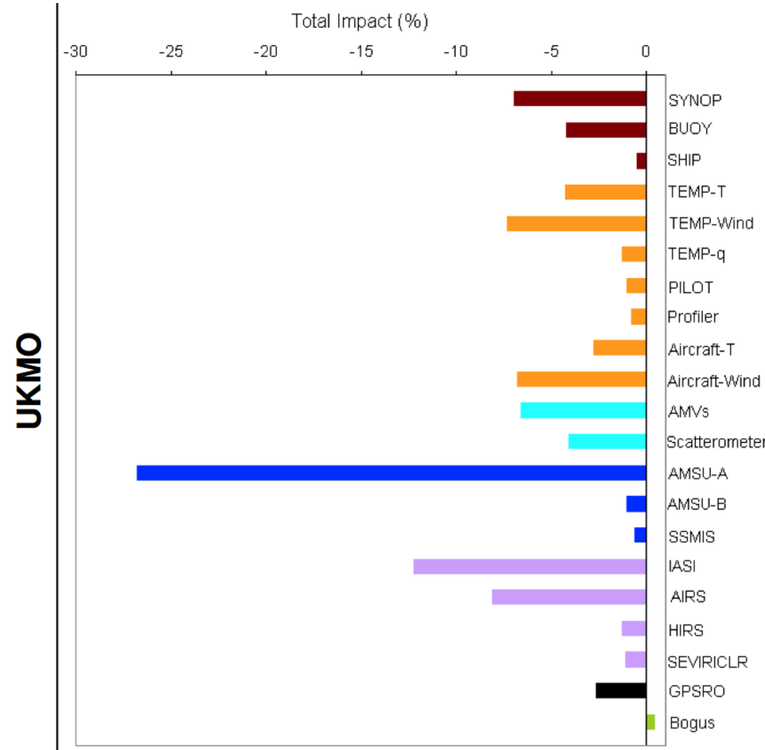
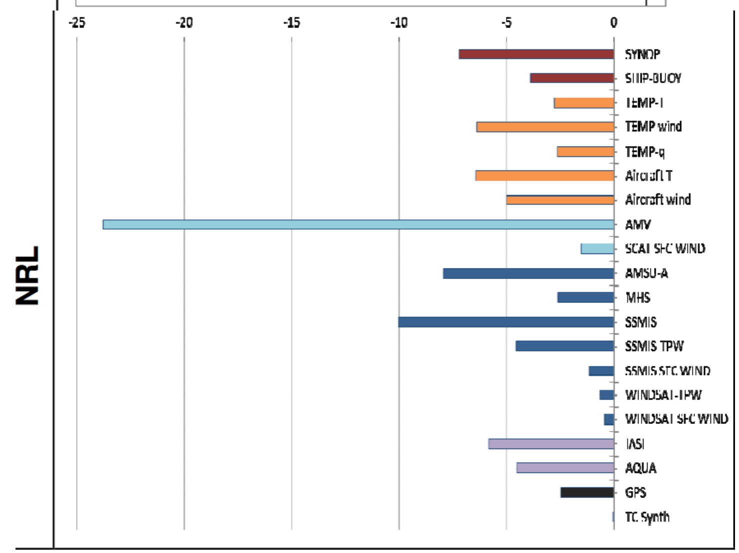


FIG. 1. Comparison of the observation impact of major categories of observations, as specified by the subtype column of Table 2. The fraction of the total observation impact is expressed as a percentage.



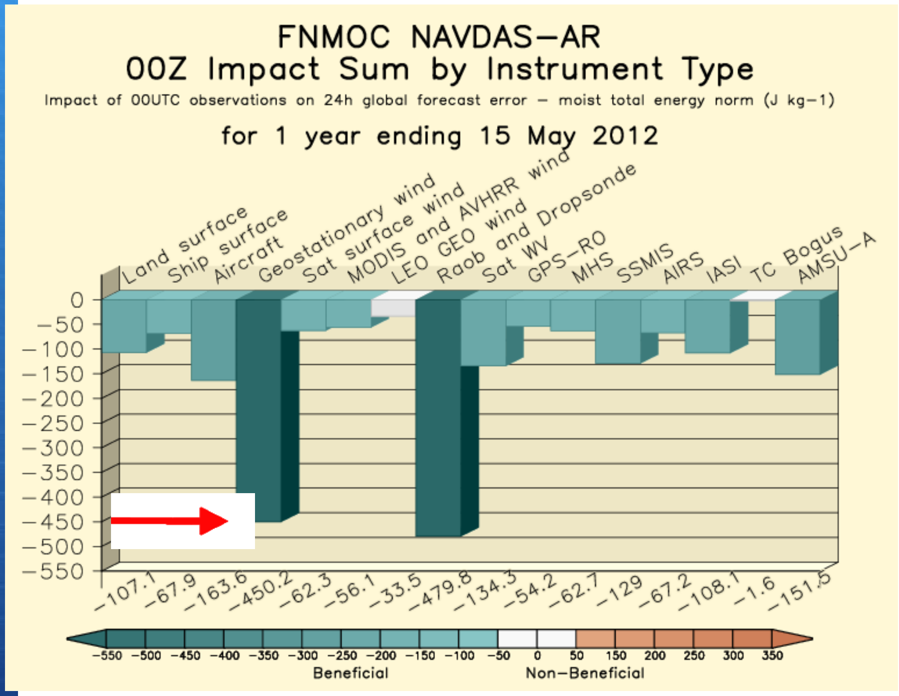


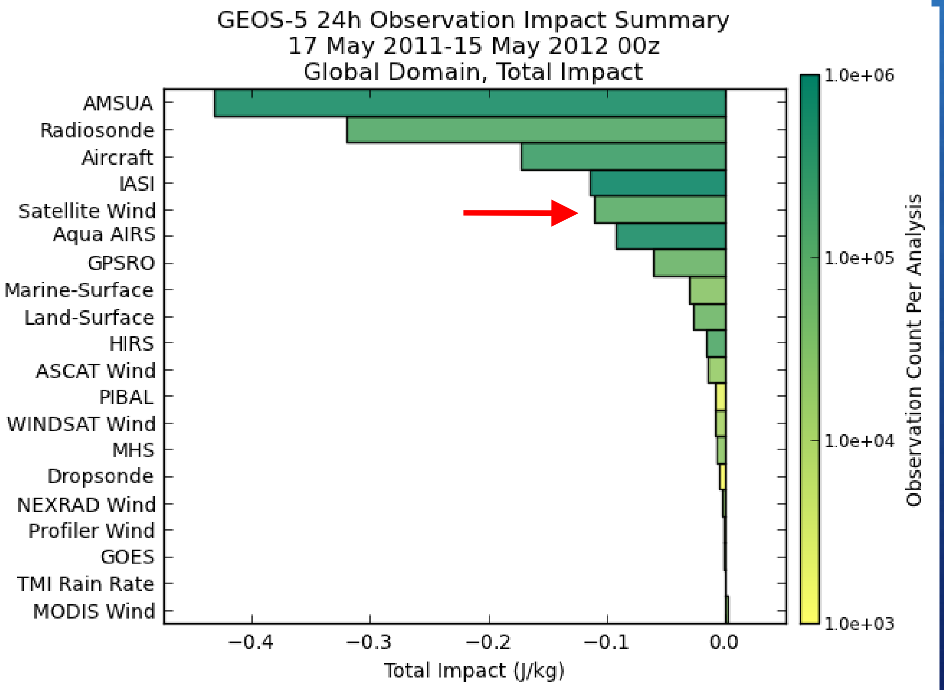


Comparisons of FSOs from ECWMF, UKMO, NRL

FNMOC and GMAO Observation Impact Monitoring

Operations for year ending 15 May 2012





http://www.nrlmry.navy.mil/obsens/fnmoc/obsens_main_od.html

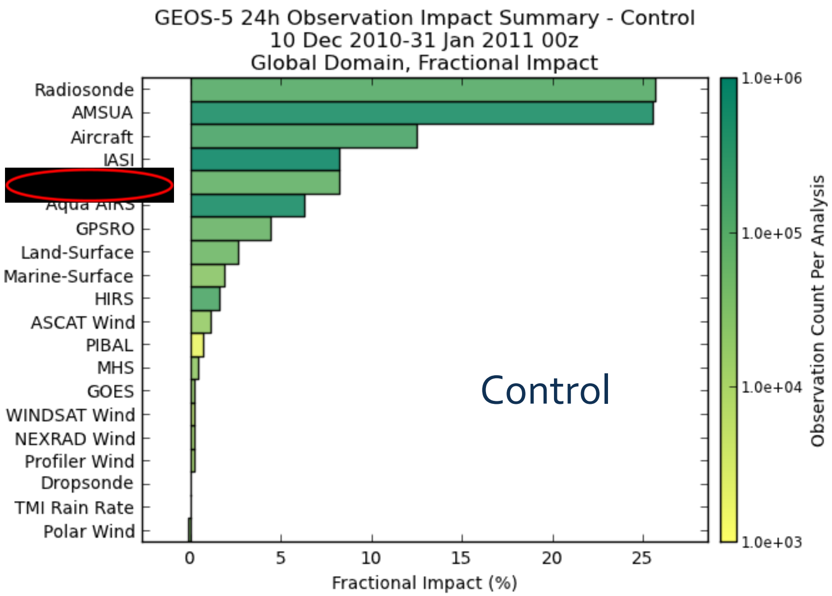
http://gmao.gsfc.nasa.gov/products/forecasts/systems/fp/obs_impact/

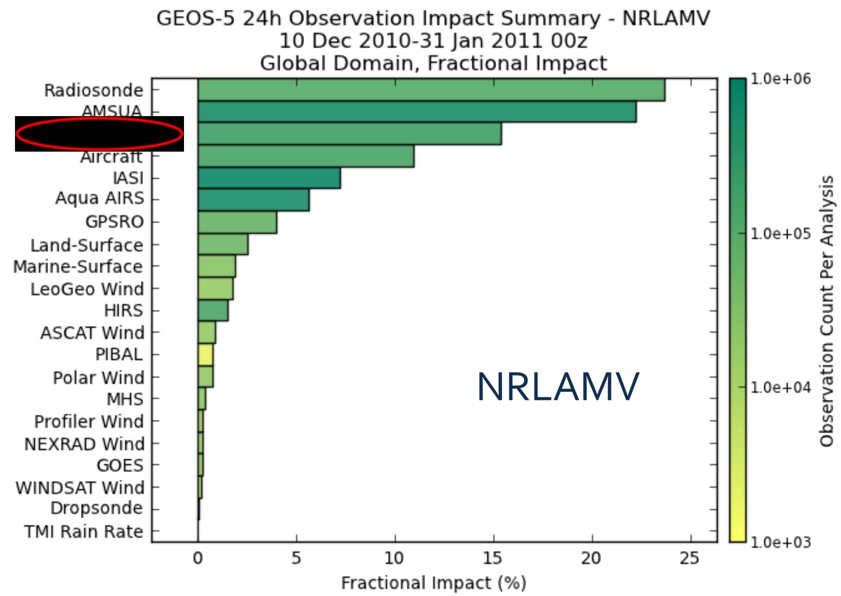
Much larger relative impact of AMVs in Navy system

Source: Ron Gelaro, GMAO

Why does NRL get more impact from Polar Winds?

Dec – Jan 2011





Observation Counts per 6h (K)

Notable observing system differences:

	Satwind	AMSU-A	Hyps IR	All Obs
GMAO	90	**520**	**1220**	2500
FNMOC	**350**	350	800	2200

Approximate average values for the year ending 15 May 2012

GMAO: 1.5x Radiances

FNMOC: 4x Winds

Most winds from UW CIMSS

Source: Ron Gelaro, GMAO

From Satellite Perspective for NWP our critical data are

- Hyperspectral Infrared Sounders (HSIRS)
- Microwave Atmospheric Sounders (MWS)
- GEO and LEO Atmospheric Motion Vector Winds (AMVs)
- Scatterometers
- GPS Radio Occultation (GPSRO)
- Microwave Imagers (MWI)
  - Ice/snow, surface temperatures, soil moisture, snow water equivalent, total precipitable water, total water content, and precipitation, wind speed, sea surface temperature
- Visible and Infrared Surface Imaging (VISI)
  - Land/sea/ice surface temperature
  - Vegetation fraction/greenness
  - Snow /Ice Cover
  - Surface emissivity/albedo

HSIR & MW Sounders

- Three orbit constellation required to provide full global coverage every six hours
- Afternoon orbit
  - NOAA (13:30) – SNPP (2011), JPSS-1 (2017), JPSS-2 (2021)
    - 5 year launches, 7 year life, extended mission for given satellite to 11 years
    - Objective to be at least two failures from a gap
  - CMA (14:00) - FY3D (2015), FY3E (2020)*
  - Russia (15:30) – Meteor-M N2-1 (2015-2020), N2-3 (2019-2024), N2-5 (2021-2026)
- * includes GPSRO

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Satellite: JPSS-2

Satellite details

Acronym	JPSS-2		
Full name	Joint Polar Satellite System - 2		
Satellite Description	• 2nd flight unit of JPSS. • Main mission: operational meteorology. • Substantial contribution to atmospheric chemistry, climatology and space weather.		
Mass at launch		Dry mass	
Power			
Data access link			
Orbit	Sunsynchronous orbit	Altitude	824 km
ECT	13:30 asc		

Space agency	NOAA , NASA		
Status	Planned		
Details on Status (as available)			
Launch	≥2022	EOL	≥2029
Last update:	2014-08-04		

Associated satellite programme and related satellites

Note: red tag: no longer operational , green tag: operational , blue tag : future

- Joint Polar Satellite System
  - JPSS-1 (2017 - 2024)
  - **JPSS-2** (2022 - 2029)
  - JPSS-FF-1 (2016 - 2021)
  - JPSS-FF-2 (2021 - 2026)

Satellite Payload

All known Instruments flying on JPSS-2

Acronym	Full name
ATMS	Advanced Technology Microwave Sounder
CrIS	Cross-track Infrared Sounder
OMPS-limb	Ozone Mapping and Profiler Suite
OMPS-nadir	Ozone Mapping and Profiler Suite
VIIRS	Visible/Infrared Imager Radiometer Suite
CERES-FO	CERES (Clouds and the Earth's Radiant Energy System) follow-on

Satellite: FY-3D

Satellite details

Acronym	FY-3D		
Full name	Feng-Yun 3D		
Satellite Description	• 4th flight unit of the FY-3 series. • Main mission: operational meteorology. • Substantial contribution to ocean and ice monitoring, climate monitoring, atmospheric chemistry and space weather.		
Mass at launch	2300 kg	**Dry mass**	2250 kg
Power	2500 W		
Data access link			
Orbit	Sunsynchronous orbit	**Altitude**	836 km
ECT	14:00 asc		

Space agency	CMA , NRSCC		
Status	Planned		
Details on Status (as available)			
Launch	≥2015	**EOL**	≥2020
Last update:	2014-08-04		

Associated satellite programme and related satellites

Note: red tag: no longer operational , green tag: operational , blue tag : future

- **Feng-Yun - 3**
  - FY-3A (2008 - 2014)
  - FY-3B (2010 - 2015)
  - FY-3C (2013 - 2018)
  - **FY-3D** (2015 - 2020)
  - FY-3E (2018 - 2023)
  - FY-3F (2020 - 2025)
  - FY-3G (2022 - 2027)

Satellite Payload

All known Instruments flying on FY-3D

Acronym	Full name
HIRAS	Hyperspectral Infrared Atmospheric Sounder
GAS	Greenhouse-gases Absorption Spectrometer
GNOS	GNSS Radio Occultation Sounder
MERSI-2	Medium Resolution Spectral Imager -2
MWHS-2	Micro-Wave Humidity Sounder -2
MWRI	Micro-Wave Radiation Imager
MWTS-2	Micro-Wave Temperature Sounder - 2
SES/IPM	SES / Ionospheric PhotoMeter
SES/WAI	SES / Wide-field Auroral Imager
SES/SEM	SES / SEM

Satellite: Meteor-M N2

Satellite details

Acronym	Meteor-M N2		
Full name	Meteor-M Number 2		
Satellite Description	• 2nd flight unit of the Meteor-M series. 3rd of the Meteor-3M programme. • Main mission: operational meteorology. • Substantial contribution to land observation and space weather.		
Mass at launch	2900 kg	**Dry mass**	
Power	2000 W		
Data access link			
Orbit	Sunsynchronous orbit	**Altitude**	836 km
ECT	09:30 desc		

Space agency	RosHydroMet , Roscosmos		
Status	Commissioning		
Details on Status (as available)			
Launch	2014-07-08	**EOL**	≥2019
Last update:	2014-08-06		

Associated satellite programme and related satellites

Note: red tag: no longer operational , green tag: operational , blue tag : future

- Meteor-3M
  - Meteor-3M (2001 - 2006)
  - Meteor-M N1 (2009 - 2014)
  - **Meteor-M N2** (2014 - 2019)
  - Meteor-M N2-1 (2015 - 2020)
  - Meteor-M N2-2 (2016 - 2021)
  - Meteor-M N2-3 (2019 - 2024)
  - Meteor-M N2-4 (2020 - 2025)
  - Meteor-M N2-5 (2021 - 2026)
  - Meteor-M N3 (2020 - 2025)
  - Meteor-MP N1 (2024 - 2029)
  - Meteor-MP N2 (2025 - 2030)
  - Meteor-MP N3 (2025 - 2030)

Satellite Payload

All known Instruments flying on Meteor-M N2

Acronym	Full name
IKFS-2	Infrared Fourier Spectrometer - 2
KMSS	High-resolution VIS/IR Radiometer
MSU-MR	VIS/IR Imaging Radiometer
MTVZA-GY	Imaging/Sounding Microwave Radiometer - improved
Severjanin-M	X-band Synthetic Aperture Radar
SSPD	Data Collection and Transmission System
GGAK-M/MSGI-MKA	GGAK-M / Spectrometer for Geoactive Measurements
GGAK-M/KGI-4C	GGAK-M / Radiation Monitoring System

HSIR & MW Sounders

- Three orbit constellation required to provide full global coverage every six hours
- Mid morning orbit
  - EUMETSAT (9:30) – Metop-B(2012-2018), -C (2018-2024), -Metop-SG-A1 (2021-2028) , A2(2028-2035), A3(2035-2042)*
    - 7 year launches, 7 year life, replacement policy is 6 months prior to expected end-of-life.
  - CMA (10:00) – FY3C (2013-2018)
  - Russia (9:30) – Meteor-M N2 (2014-2019), N2-2 (2016-2021), N2-4 (2020-2025)

* includes GPSRO

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Satellite: Metop-SG-A1

Satellite details

Acronym	Metop-SG-A1		
Full name	Metop Second Generation - A1		
Satellite Description	• 1st flight unit of MetOp-SG, 1st of the "A" type. • Main mission: operational meteorology. • Substantial contribution to climate monitoring and atmospheric chemistry.		
Mass at launch		**Dry mass**	
Power			
Data access link			
Orbit	Sunsynchronous orbit	**Altitude**	817 km
ECT	09:30 desc		

Space agency	EUMETSAT , ESA		
Status	Considered		
Details on Status (as available)			
Launch	≥2021	**EOL**	≥2028
Last update:	2013-06-13		

Associated satellite programme and related satellites

Note: red tag: no longer operational , green tag: operational , blue tag : future

- EPS Second Generation
  - **Metop-SG-A1** (2021 - 2028)
  - Metop-SG-A2 (2028 - 2035)
  - Metop-SG-A3 (2035 - 2042)
  - Metop-SG-B1 (2022 - 2029)
  - Metop-SG-B2 (2030 - 2037)
  - Metop-SG-B3 (2036 - 2043)

Satellite Payload

All known Instruments flying on Metop-SG-A1

Acronym	Full name
3MI	Multi-viewing Multi-channel Multi-polarisation Imager
IASI-NG	Infrared Atmospheric Sounder Interferometer - New Generation
Sentinel-5	UVNS: Ultra-violet, Visible and Near-infrared Sounder
MetImage	Meteorological Imager (Previous name: VII - Visible and Infrared Imager)
MWS	Micro-Wave Sounder
RO	Radio Occultation sounder

Satellite: Meteor-M N2

Satellite details

Acronym	Meteor-M N2		
Full name	Meteor-M Number 2		
Satellite Description	• 2nd flight unit of the Meteor-M series. 3rd of the Meteor-3M programme. • Main mission: operational meteorology. • Substantial contribution to land observation and space weather.		
Mass at launch	2900 kg	**Dry mass**	
Power	2000 W		
Data access link			
Orbit	Sunsynchronous orbit	**Altitude**	836 km
ECT	09:30 desc		

Space agency	RosHydroMet , Roscosmos		
Status	Commissioning		
Details on Status (as available)			
Launch	2014-07-08	**EOL**	≥2019
Last update:	2014-08-06		

Associated satellite programme and related satellites

Note: red tag: no longer operational , green tag: operational , blue tag : future

- **Meteor-3M**
  - Meteor-3M (2001 - 2006)
  - Meteor-M N1 (2009 - 2014)
  - **Meteor-M N2** (2014 - 2019)
  - Meteor-M N2-1 (2015 - 2020)
  - Meteor-M N2-2 (2016 - 2021)
  - Meteor-M N2-3 (2019 - 2024)
  - Meteor-M N2-4 (2020 - 2025)
  - Meteor-M N2-5 (2021 - 2026)
  - Meteor-M N3 (2020 - 2025)
  - Meteor-MP N1 (2024 - 2029)
  - Meteor-MP N2 (2025 - 2030)
  - Meteor-MP N3 (2025 - 2030)

Satellite Payload

All known Instruments flying on Meteor-M N2

Acronym	Full name
IKFS-2	Infrared Fourier Spectrometer - 2
KMSS	High-resolution VIS/IR Radiometer
MSU-MR	VIS/IR Imaging Radiometer
MTVZA-GY	Imaging/Sounding Microwave Radiometer - improved
Severjanin-M	X-band Synthetic Aperture Radar
SSPD	Data Collection and Transmission System
GGAK-M/MSGI-MKA	GGAK-M / Spectrometer for Geoactive Measurements
GGAK-M/KGI-4C	GGAK-M / Radiation Monitoring System

HSIR & MW Sounders

- Three orbit constellation required to provide full global coverage every six hours

- Early morning orbit
  - CMA (6:00) – FY3E(2018-2023), -FY3G (2022-2027),
  - Replacement policy is ~12 months prior to expected end-of-life.

Satellite: FY-3E

Satellite details

Acronym	FY-3E		
Full name	Feng-Yun 3E		
Satellite Description	• 5th flight unit of the FY-3 series. • Main mission: operational meteorology. • Substantial contribution to ocean and ice monitoring, climate monitoring, atmospheric chemistry and space weather.		
Mass at launch	2300 kg	**Dry mass**	2250 kg
Power	2500 W		
Data access link			
Orbit	Sunsynchronous orbit	**Altitude**	836 km
ECT	06:00 desc		

Space agency	CMA , NRSCC		
Status	Planned		
Details on Status (as available)			
Launch	≥2018	**EOL**	≥2023
Last update:	2014-08-04		

Associated satellite programme and related satellites

Note: red tag: no longer operational , green tag: operational , blue tag : future

- **Feng-Yun - 3**
  - FY-3A (2008 - 2014)
  - FY-3B (2010 - 2015)
  - FY-3C (2013 - 2018)
  - FY-3D (2015 - 2020)
  - **FY-3E** (2018 - 2023)
  - FY-3F (2020 - 2025)
  - FY-3G (2022 - 2027)

Satellite Payload

All known Instruments flying on FY-3E

Acronym	Full name
HIRAS	Hyperspectral Infrared Atmospheric Sounder
ERM-2	Earth Radiation Measurement - 2
GNOS	GNSS Radio Occultation Sounder
MERSI-2	Medium Resolution Spectral Imager -2
MWHS-2	Micro-Wave Humidity Sounder -2
MWTS-2	Micro-Wave Temperature Sounder - 2
OMS-nadir	Ozone Monitoring Suite - nadir scanning unit
SIM-2	Solar Irradiance Monitor - 2
WindRAD	Wind Radar
OMS-limb	Ozone Monitoring Suite - limb scanning unit
SES/IPM	SES / Ionospheric PhotoMeter
SES/WAI	SES / Wide-field Auroral Imager
SES/SEM	SES / SEM

MW Sounders - only

- Three orbit constellation required to provide full global coverage every six hours
- Early morning
  - DoD (5:30) – F19(2014-2020), F20 – unfunded.
  - KMA (5:30 – 7:30) ~ 2021?? (early stages of planning)
- Mid morning
  - CMA (10:00) – FY3C (2013-2018)
    - Also HIRS-like infrared sounder (but not hyperspectral)

Satellite: DMSP-F19

Satellite details

Acronym	DMSP-F19		
Full name	Defense Meteorological Satellite Program - S19		
Satellite Description	• 19th flight unit of the DMSP Block 5D series, 5th of the Block 5D-3 series. • Main missions: cloud imagery and MW imaging/temperature/humidity sounding. • Substantial contribution to Space weather.		
Mass at launch	1220 kg	**Dry mass**	
Power	2200 W		
Data access link			
Orbit	Sunsynchronous orbit	**Altitude**	850 km
ECT	05:30 desc		

Space agency	DoD , NOAA		
Status	Commissioning		
Details on Status (as available)			
Launch	2014-04-03	**EOL**	≥2019
Last update:	2014-08-04		

Associated satellite programme and related satellites

Note: red tag: no longer operational , green tag: operational , blue tag : future

- Defense Meteorological Satellite Program - Block 5D-3
  - DMSP-F15 (1999 - 2014)
  - DMSP-F16 (2003 - 2014)
  - DMSP-F17 (2006 - 2014)
  - DMSP-F18 (2009 - 2014)
  - **DMSP-F19** (2014 - 2019)
  - DMSP-S20 (2020 - 2025)

Satellite Payload

All known Instruments flying on DMSP-F19

Acronym	Full name
OLS	Operational Linescan Systerm
SSMIS	Special Sensor Microwave - Imager/Sounder
SESS/SSUSI	SESS / Special Sensor Ultraviolet Spectrographic Imager
SESS/SSULI	SESS / Special Sensor Ultraviolet Limb Imager
SESS/SSI/ES-2	SESS / Special Sensor Ionospheric Plasma Drift/Scintillation Monitor - 2
SESS/SSM	SESS / Special Sensor Magnetometer
SESS/SSJ5	SESS / Special Sensor Precipitating Electron and Ion Spectrometer

HSIR – only satellites - GEO

- EUMETSAT MTG-S1(2021-2029), MTG-S2(2029-2037)
- CMA FY-4A (2016-2022) …FY-4G(2033-2040)
  - West (86.5) and East (105)

Satellite: MTG-S1

Satellite details

Acronym	MTG-S1		
Full name	Meteosat Third Generation - Sounding 1		
Satellite Description	• 2nd flight unit of MTG, 1st of the "S" type. • Mission: operational meteorology. • Substantial contribution to atmospheric chemistry.		
Mass at launch		**Dry mass**	
Power			
Data access link			
Orbit	Geostationary orbit	**Altitude**	35786 km
Longitude	0°		

Space agency	EUMETSAT , EC, ESA		
Status	Planned		
Details on Status (as available)			
Launch	≥2021	**EOL**	≥2029
Last update:	2014-08-04		

Associated satellite programme and related satellites

Note: red tag: no longer operational , green tag: operational , blue tag : future

Meteosat Third Generation (MTG) - "I" imaging, "S" sounding
- MTG-I1 (2019 - 2027)
- MTG-I2 (2023 - 2031)
- MTG-I3 (2027 - 2035)
- MTG-I4 (2031 - 2039)
- **MTG-S1** (2021 - 2029)
- MTG-S2 (2029 - 2037)

Satellite Payload

All known Instruments flying on MTG-S1

Acronym	Full name
DCS	Data Collection Service
GEOS&R	Geostationary Search and Rescue
IRS	Infra Red Sounder
Sentinel-4	UVN: Ultra-violet, Visible and Near-infrared sounder

Satellite Field of View

Estimate of the satellite's footprint, assuming a zenith angle of 75 °
You can drag the image around and zoom using the mousewheel

Satellite: FY-4B

Satellite details

Acronym	FY-4B		
Full name	Feng-Yun - 4B		
Satellite Description	• 2nd flight unit of the FY-4 programme. • Mission: operational meteorology. • Substantial contribution to space weather.		
Mass at launch	5300 kg	**Dry mass**	
Power	3200 W		
Data access link			
Orbit	Geostationary orbit	**Altitude**	35786 km
Longitude	105° E		

Space agency	CMA , NRSCC		
Status	Planned		
Details on Status (as available)			
Launch	≥2019	**EOL**	≥2026
Last update:	2014-08-04		

Associated satellite programme and related satellites

Note: red tag: no longer operational , green tag: operational , blue tag : future

- Feng-Yun - 4
  - FY-4A (2016 - 2022)
  - **FY-4B** (2019 - 2026)
  - FY-4C (2021 - 2028)
  - FY-4D (2023 - 2030)
  - FY-4E (2027 - 2034)
  - FY-4F (2030 - 2037)
  - FY-4G (2033 - 2040)

Satellite Payload

All known Instruments flying on FY-4B

Acronym	Full name
DCS	Data Collection Service
GIIRS	Geostationary Interferometric Infrared Sounder
LMI	Lightning Mapping Imager
AGRI	Advanced Geostationary Radiation Imager
SEMIP	Space Environment Monitoring Instrument Package
SXEUV	Solar X-EUV imaging telescope

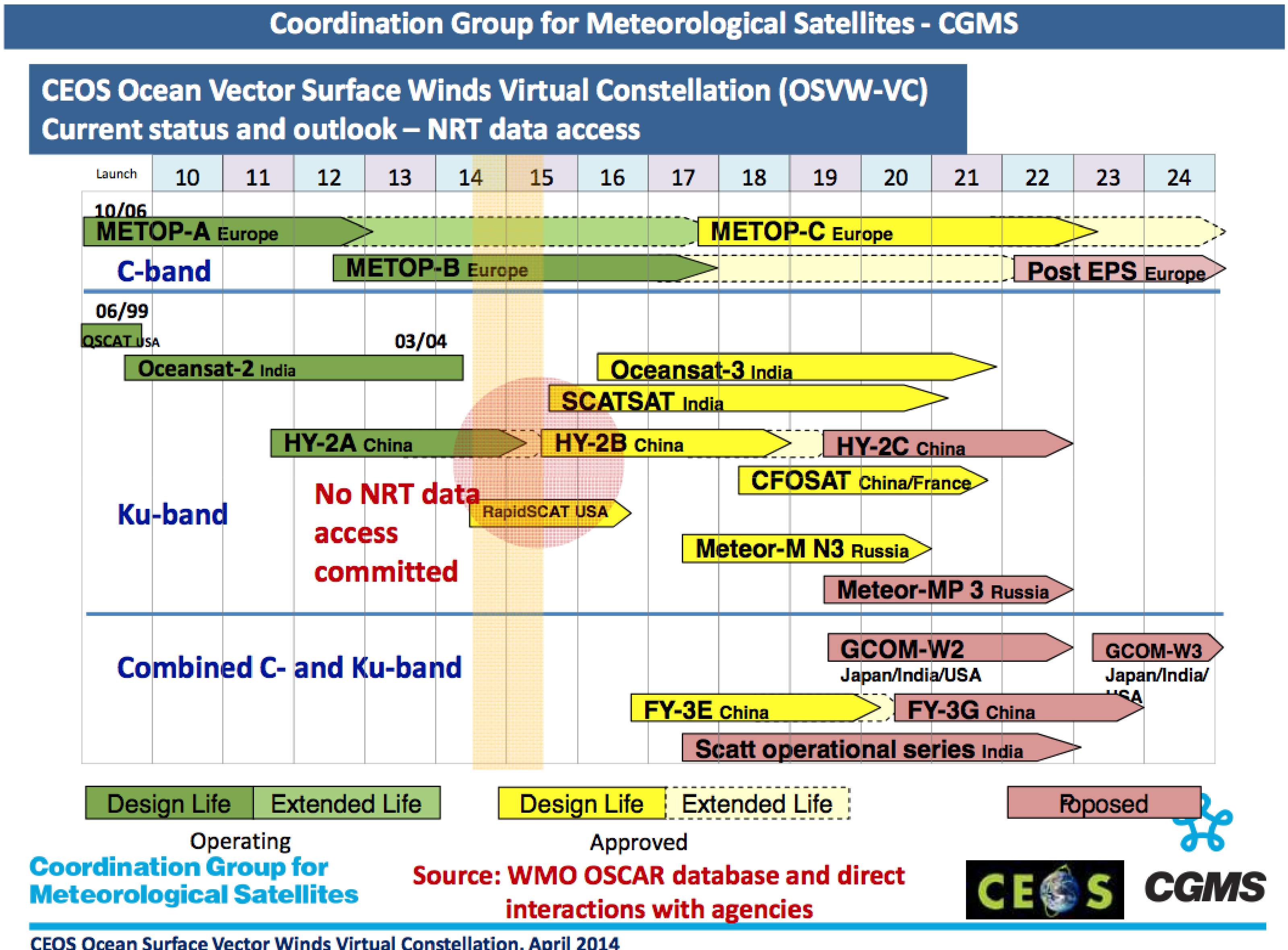
Satellite Field of View

Estimate of the satellite's footprint, assuming a zenith angle of 75 °
You can drag the image around and zoom using the mousewheel

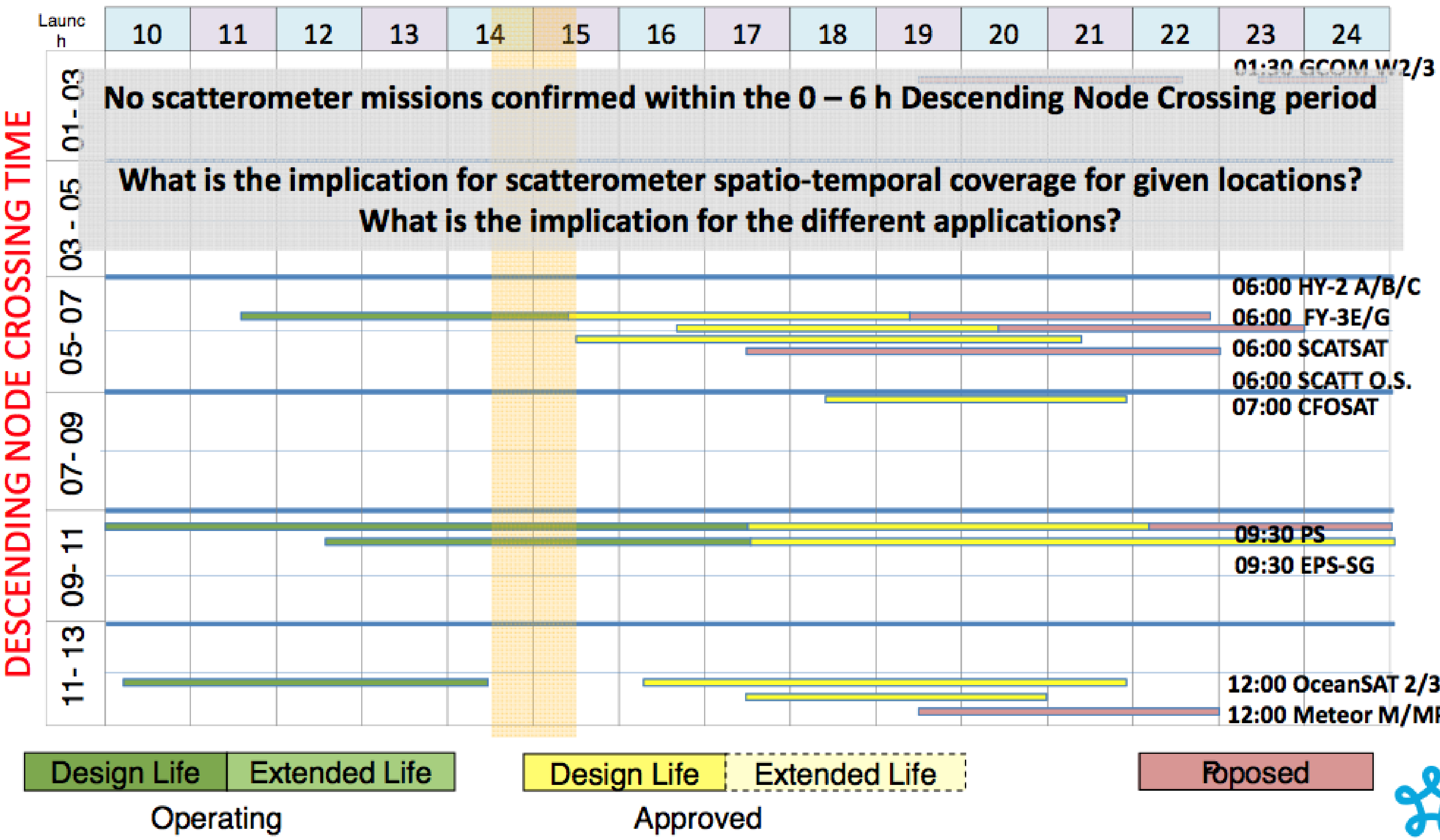
AMVs

- Multi channels (~>14) geostationary imagers covering the entire globe with higher refresh will become available starting in ~2015.
  - Expect improved accuracy and temporal sampling and spatial resolution
  - KMA, JMA, NOAA (all ABI-like imagers), EUMETSAT, CMA, Russia (go from 10 to 20 channels in 2020's)
  - India – six GOES-classic channels
- Polar orbiting imagers are in good shape - more channels and higher spatial resolution.
- NOAA VIIRS has no water vapor channel (consider for JPSS-3, -4 to add WV channel)

Scatterometers



CEOS Ocean Vector Surface Winds Virtual Constellation (OSVW-VC)
Overall assessment of the local time coverage planned (ground track)



Coordination Group for Meteorological Satellites

Source: WMO OSCAR database and direct interactions with agencies

Summary and conclusions to be considered by CGMS:

- The discontinuation of OSCAT operations and the current unavailability of HY-2A winds in NRT has a significant impact on short term weather forecasting applications. **It it essential to secure as soon as possible open NRT data access from the HY-2A scatterometer , SCATSAT and RapidSCAT to the global forecasting community**

- The mission chart suggests numerous missions over the next decade but only a few of these are part of sustained programs. There is a need for **long-term international commitment to a sustained global vector winds constellation**, to support on one hand short term extreme weather forecasting and warning, and on the other hand long-term earth system forecasting monitoring

- As more and more scatterometer missions are planned and approved, a closer look is necessary at the **optimum combination of orbit local times**, in order to make sure that the overall daily coverage is able to represent faithfully and in an unaliased way the mesoscale convective systems, hurricanes and the diurnal variations and trends of the surface wind field.

Radio Occultation

http://irowg.org/wpcms/wp-content/uploads/2013/12/Status_Global_Observing_System_for_RO.pdf

- The NWP and IROWG communities have identified a need for at least 10,000 and preferably 16,000 occultations per day, regularly distributed in time and space. This cannot be achieved before 2020 without both COSMIC-2/FORMOSAT-7 constellations in equatorial and polar orbit. The operational EPS mission will add about 1,300 to the Global Observing System, and the new Chinese mission may further add about 1,300 once its data quality is proven. Arrangements have to be made in order to assure an operational baseline of at least 10,000 to 16,000 occultations after the end of COSMIC-2/FORMOSAT-7.
- There are currently about 3,000 occultations available per day in Near Real Time (NRT). These are primarily provided by the operational GRAS on Metop-B and Metop-A (which continues to provide data in the same orbit), in total about 1,300 occultations. About 1,700 occultations are provided by non-operational missions: the COSMIC-1/FORMOSAT-3 constellation (about 1,300), GRACE (about 100), and TerraSAR-X (about 180).
- Truly operational data are expected to be provided by the COSMIC-2/FORMOSAT-7 (equatorial) constellation from 2016 onwards, with at least 4,000 occultations per day, building on COSMIC-1/FORMOSAT-3 heritage, and by EPS-SG satellites from 2021, with at least 2,000 occultations per day. This leaves a strong under representation of mid-latitude and polar observations that will only be solved with the implementation of the COSMIC- 2/FORMOSAT-7 (polar) constellation, which however is not fully funded to-date.

GPSRO

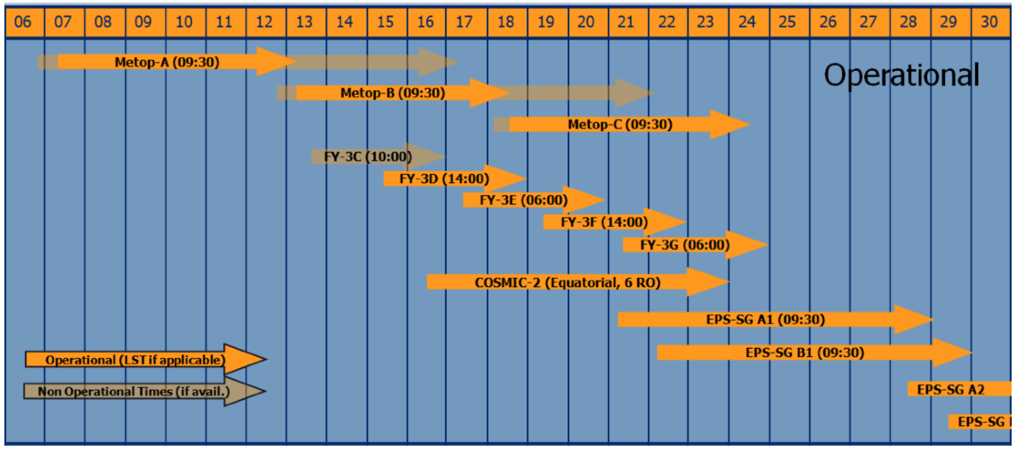


Figure 1 Operational RO missions, the local solar equator crossing time (LST) is given in brackets where applicable. Commissioning periods, pre-operational service, or extended service after the end of full operational service is indicated in lighter orange where available.

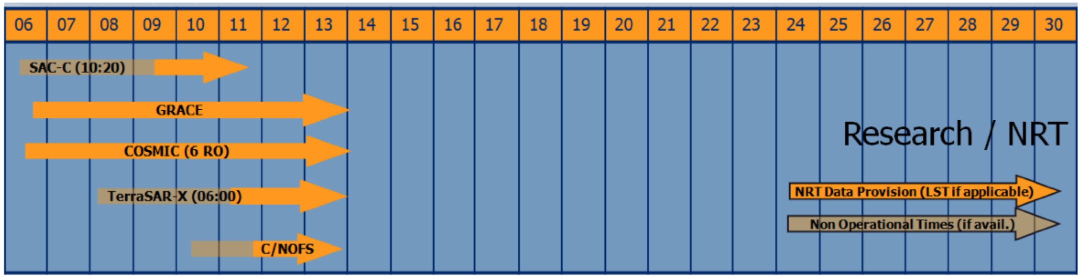


Figure 2 Research/NRT missions, the local solar equator crossing time (LST) is given in brackets where applicable. Periods with data that was not available in NRT (but is still useful for climate) are shown in lighter orange.

GPSRO

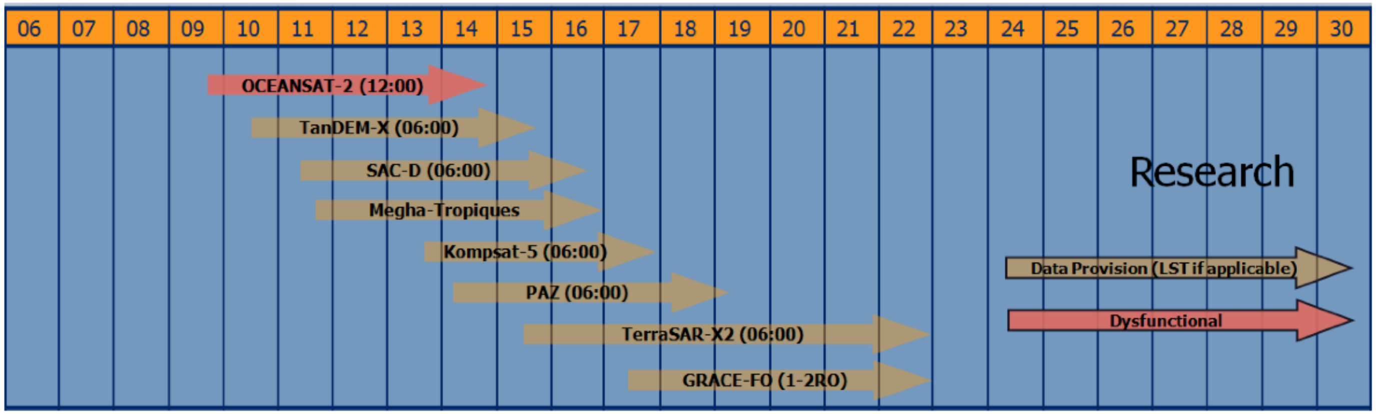


Figure 3 Research missions that could potentially provide NRT or data for climate assessments, the local solar equator crossing time (LST) is given in brackets where applicable.

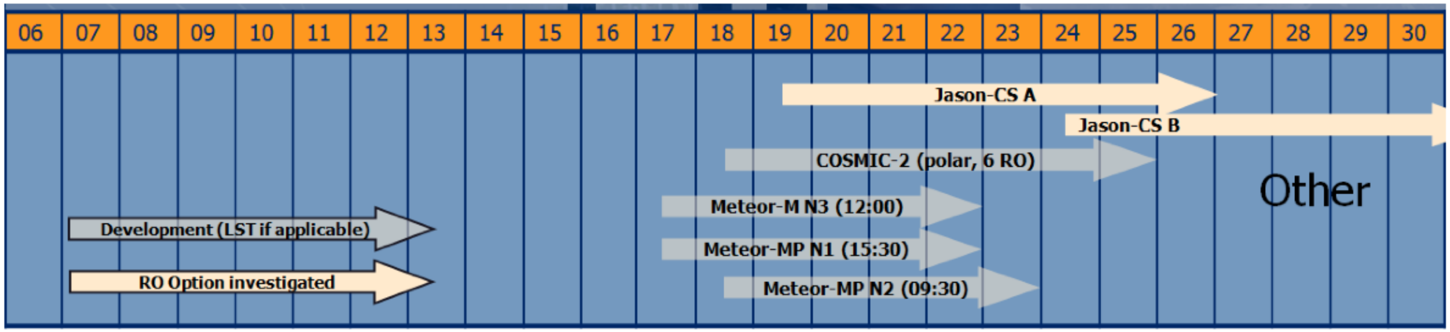


Figure 4 Other missions that could potentially provide NRT or data for climate assessments, the local solar equator crossing time (LST) is given in brackets where applicable.

GPSRO

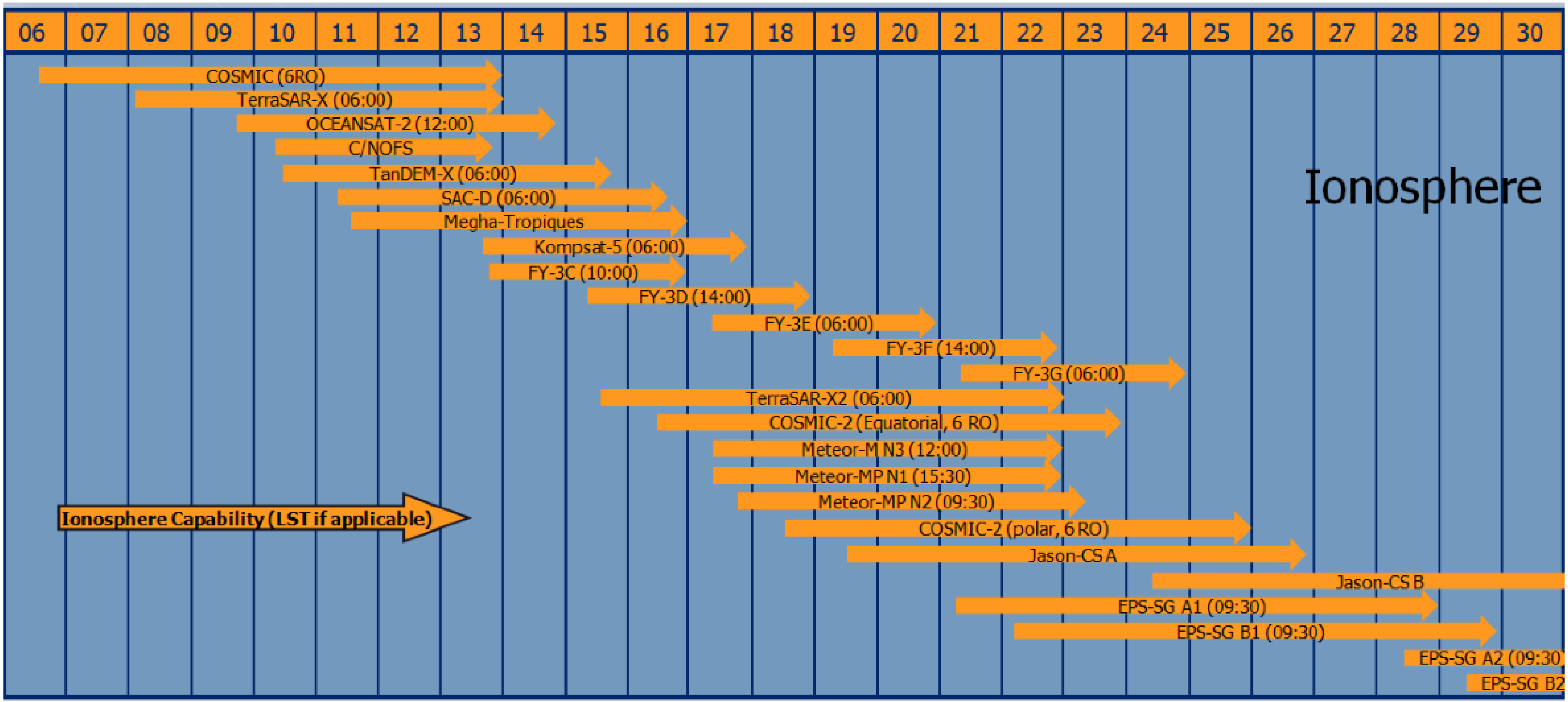


Figure 5 RO missions that provide ionospheric profiling capability, the local solar equator crossing time (LST) is given in brackets where applicable.

Radio Occultation

- About 10,000 per day - early 2020's, however COSMIC-2 polar satellites is on the critical path to reach the 16000 goal.

Instrument	Satellite	# of obs/day	years	Agency
Radiomet	METEOR-3M (2 sats)	~1300	2020-2030	Roshydromet /Roscomos
RO	EPSG-A1/A2	~1300	2021 - 2042	EUMETSAT
GNOS	FY3C+ (2 sats)	~1300	2014-2020's	CMA
COSMIC-2	6 equatorial satellites	~4500	2016 - 2025	NOAA, NASA, DoD, Taiwan
JASON-CS	JASON	~2000	2018-2025	NOAA, NASA,EUMETSAT, ESA, CNES

MWI – operational conical imagers

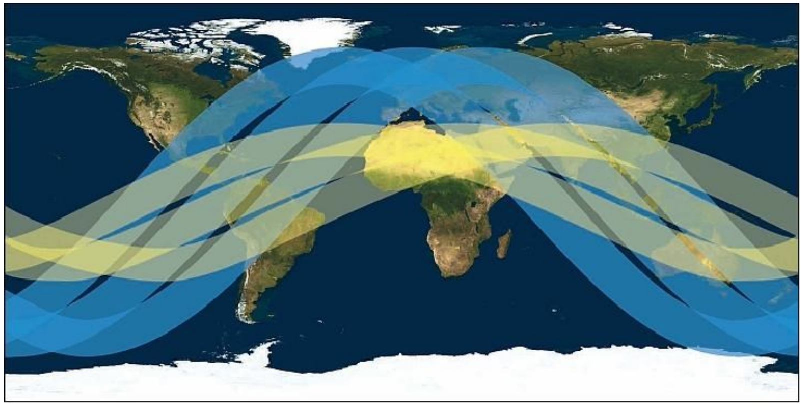
- Early morning
  - SSMIS until ~ 2020, likely DoD follow-on.
    - SSMIS include temperature and water vapor soundings.
    - DoD follow-on still pending
  - NSOAS,CAST – HY-2C (6:00) - HY2A (2011-2014), HY2B(2016-2019),HY2C(2019-2022),HY-2D(2022-2025)

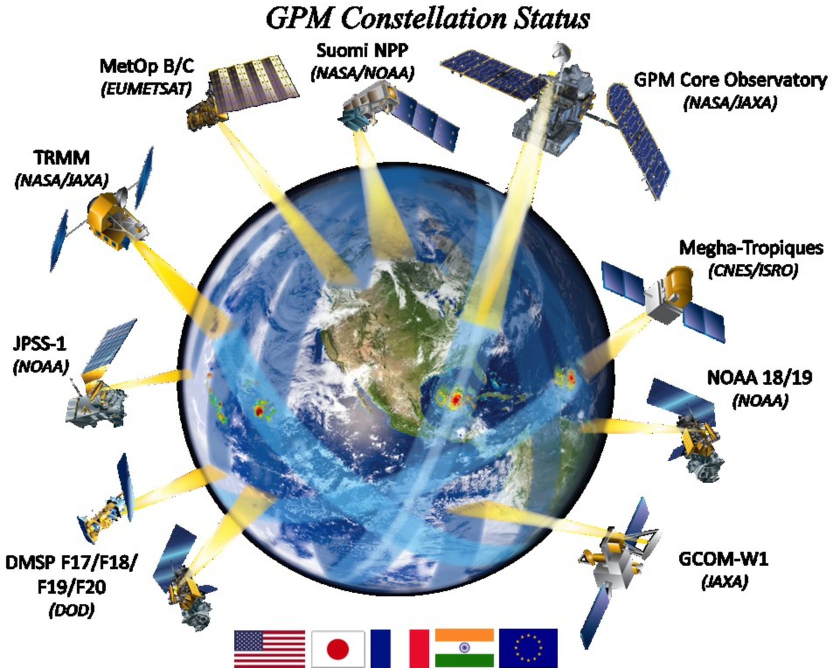
- Mid morning
  - EUMETSAT (9:30) -Metop-SG-B1 (2021-2028) , B2(2028-2035), B3(2035-2042) INCLUDES water vapor sounding channels
  - Russia (9:30) – Meteor-M N2 (2014-2019), N2-2 (2016-2021), N2-4 (2020-2025) - INCLUDES temperature and water vapor sounding channels
  - CMA (10:00) – FY3C (2013-2018)

- Afternoon
  - JAXA(13:30) – GCOM-W1-AMSR2 (2012 – 2017), GCOM-W2(2016-2021), GCOM-W3(2020-2025).
  - CMA (14:00) - FY3D (2015), FY3F (2020)
  - Russia (15:30) – Meteor-M N2-1 (2015-2020), N2-3 (2019-2024), N2-5 (2021-2026) INCLUDES temperature and water vapor sounding channels

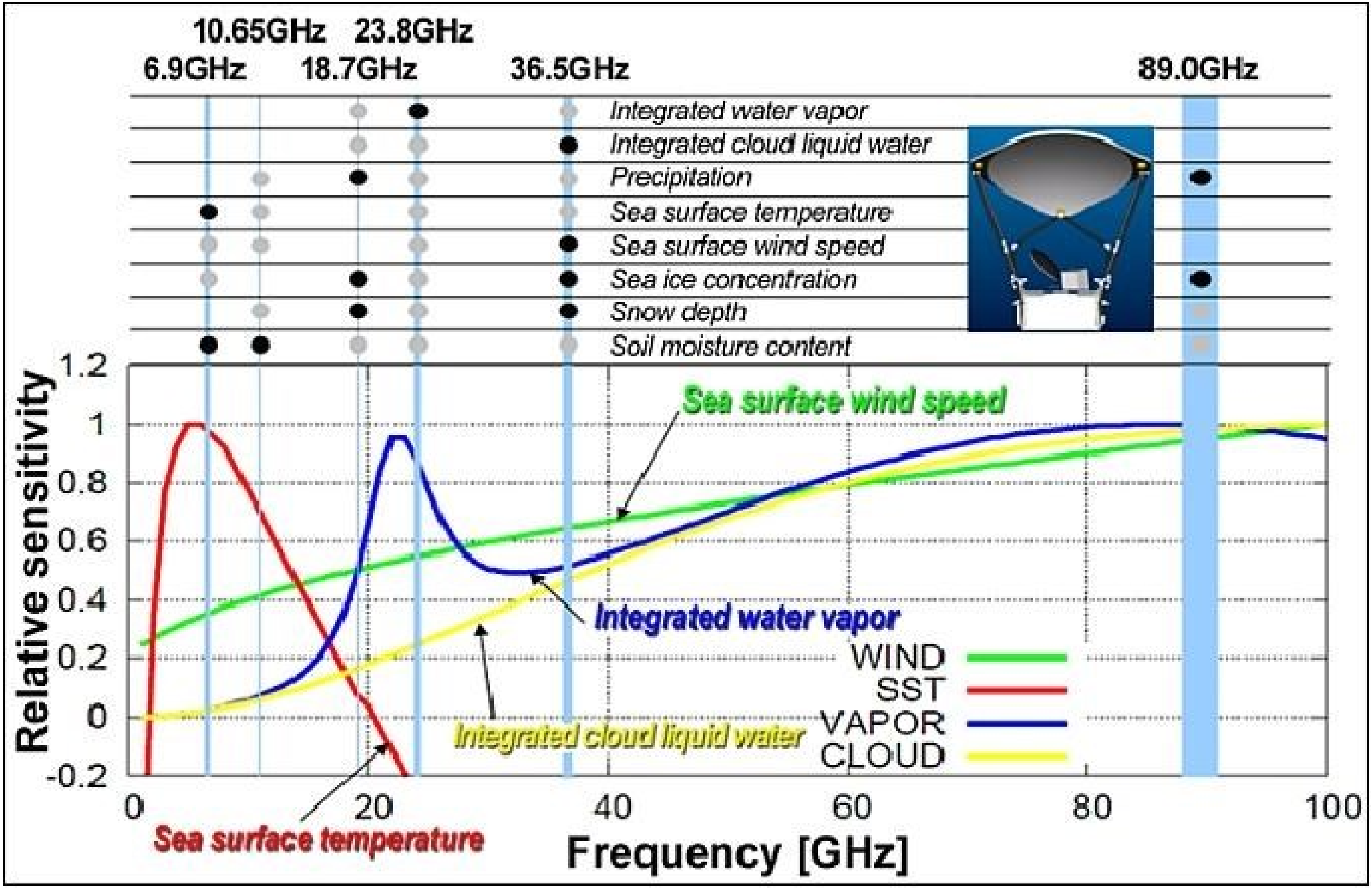
MWI -Research

- GPM - Imager and Radar : 2014 to 2020+





Soil moisture missions: SMAP and SMOS (SMOS includes salinity) exploiting 1.4 Ghz L-band



10.65GHz
23.8GHz
6.9GHz
18.7GHz
36.5GHz
89.0GHz
Integrated water vapor
Integrated cloud liquid water
Precipitation
Sea surface temperature
Sea surface wind speed
Sea ice concentration
Snow depth
Soil moisture content
Relative sensitivity
Sea surface wind speed
Integrated water vapor
Integrated cloud liquid water
Sea surface temperature
WIND
SST
VAPOR
CLOUD
Frequency [GHz]

From JAXA

MWI

Satellite	6.9	7.3	10.6	18.7	23.8	31.4	36.5	89
GCOM-W1-W3/AMSR2	X	X	X	X	X		X	X
FY3 / MWRI			X	X	X		X	X
SSMIS				X (19.35)	X		X	X (91.66)
Metop-SG-B1-B3/MWI				X	X	X		X
Meteor-M			X	X	X	X	X	X
GPM imager*			X	X	X		X	X
HY-2A-2D MWI	X		X	X	X		X	

* Also 166, 183,31+-3, and 183.31+-7

Instrument	Rating	Satellite	Orbit	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
MWRI	2	FY-3RM-1											X	X	X	X	X	X						
MWRI	2	FY-3RM-2															X	X	X	X	X	X		
MADRAS	4	Megha-Tropiques	20 °		X	X	X	X	X	X														
GMI (constellation)	2	GPM-Brazil	30 °							X	X	X	X	X	X									
TMI	4	TRMM	35 °	X	X	X	X	X																
GMI (core)	2	GPM Core Observatory	65 °					X	X	X	X													
AMSR-2	1	GCOM-W1	13:30 asc			X	X	X	X	X	X													
AMSR-2	1	GCOM-W2	13:30 asc							X	X	X	X	X	X									
AMSR-2	1	GCOM-W3	13:30 asc											X	X	X	X	X	X					
AMSR-E	1	EOS-Aqua	13:30 asc	X	X	X	X	X																
MWRI	2	FY-3B	13:40 asc	X	X	X	X	X	X															
MWRI	2	FY-3D	14:00 asc						X	X	X	X	X	X										
MWRI	2	FY-3F	14:00 asc											X	X	X	X	X	X					
SSM/I	4	DMSP-F14	15:23 asc	X	X	X	X	X																
SSM/I	4	DMSP-F15	15:24 asc	X	X	X	X	X																
MTVZA-GY	3	Meteor-M N2-1	15:30 asc						X	X	X	X	X	X										
MTVZA-GY-MP	3	Meteor-MP N1	15:30 asc															X	X	X	X	X	X	
SSMIS	3	DMSP-F16	05:22 desc	X	X	X	X	X																
SSMIS	3	DMSP-F19	05:30 desc					X	X	X	X	X	X											
SSMIS	3	DMSP-S20	05:30 desc											X	X	X	X	X	X					
SSMIS	3	DMSP-F17	05:49 desc	X	X	X	X	X																
SSM/I	4	DMSP-F13	05:51 desc	X	X	X	X	X																
MWI (HY-2A)	2	HY-2A	06:00 desc		X	X	X	X																
MWI (HY-2A)	2	HY-2B	06:00 desc							X	X	X	X											
MWI (HY-2A)	2	HY-2C	06:00 desc										X	X	X	X								
MWI (HY-2A)	2	HY-2D	06:00 desc													X	X	X	X					
MWR (SAC-D)	5	SAC-D	06:00 desc		X	X	X	X	X	X														
SSMIS	3	DMSP-F18	08:06 desc	X	X	X	X	X																
MTVZA-GY	3	Meteor-M N1	09:30 desc	X	X	X	X	X																
MTVZA-GY	3	Meteor-M N2	09:30 desc					X	X	X	X	X	X											
MTVZA-GY	3	Meteor-M N2-2	09:30 desc							X	X	X	X	X	X									
MTVZA-GY	3	Meteor-M N2-4	09:30 desc											X	X	X	X	X	X					
MTVZA-GY-MP	3	Meteor-MP N2	09:30 desc																X	X	X	X	X	X
MWI (MetOp-SG)	3	Metop-SG-B1	09:30 desc													X	X	X	X	X	X	X	X	
MWRI	2	FY-3C	10:00 desc				X	X	X	X	X	X												
MWRI	2	FY-3A	10:15 desc	X	X	X	X	X																
MTVZA-GY	3	Meteor-M N2-3	15:30 desc										X	X	X	X	X	X						
MTVZA-GY	3	Meteor-M N2-5	15:30 desc												X	X	X	X	X	X				

Visible and Infrared Surface Imaging (VISI) (polar satellites)

- Early morning
  - CMA /(MERSI)(6:00) – FY3E(2018-2023), -FY3G (2022-2027)
- Mid morning
  - EUMETSAT(AVHRR / SG- METIMAGE) (9:30) – Metop-B(2012-2018), -C (2018-2024), - Metop-SG-A1 (2021-2028) , A2(2028-2035), A3(2035-2042)
  - Russia (MSU-MR) (9:30) – Meteor-M N2 (2014-2019), N2-2 (2016-2021), N2-4 (2020-2025) - similar to AVHRR
  - CMA (MERSI) (10:00) – FY3C (2013-2018)
- Afternoon
  - NOAA (VIIRS) (13:30) – SNPP (2011), JPSS-1 (2017), JPSS-2 (2022)
  - CMA (MERSI) (14:00) - FY3D (2015), FY3F (2020)
  - Russia (MSU-MR) (15:30) – Meteor-M N2-1 (2015-2020), N2-3 (2019-2024), N2-5 (2021-2026)

Emerging satellite data

- Lidar (winds, aerosols, clouds)
- Salinity /Soil Moisture
- Lightning mappers
- Ocean Color
- Atmospheric composition.
- Altimetry

Timeline for: *Lidar observation (for wind, for cloud/aerosol, for trace gases, for altimetry)*

Timeline of current and planned Instruments contributing to this capability.

Table data can be sorted for analysis by clicking on the header columns (e.g. instrument, rating, orbit, year). Filtering by type of satellite programme is also possible

*Note: Instruments to fly on satellites which are not firmly planned are shaded with **stripes** in the table. A warning icon ((!)) indicates a degraded satellite. Hover over the icon or select the satellite to see details on the type of degradation*

Only display certain Programmes
- [ ] CGMS Operational Programme
- [ ] CGMS R&D Programme
- [ ] Other Programmes

Instrument	Rating	Satellite	Orbit	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
CATS	2	ISS CATS	51.6 °					X	X	X	X													
ATLAS	3	ICESat-2	92 °								X	X	X	X	X	X								
IPDA lidar	4	MERLIN	06:00 asc										X	X	X	X								
CO2 lidar	4	ASCENDS	10:30 asc														X	X	X	X				
CALIOP	2	CALIPSO	13:30 asc	X	X	X	X	X	X															
ALADIN	1	ADM-Aeolus	06:00 desc							X	X	X	X											
ATLID	2	EarthCARE	13:30 desc								X	X	X	X										

version 0.9.4.2

Relevant Instruments and their contribution

The rating describes how the instruments, by design, have the potential to contribute to a capability identified in the WMO Vision of global observing systems, assuming nominal operation of space and ground segments. For this particular capabilty, instrument performance is considered to be driven by:

- the wavelength(s), in UV and/or NIR and/or SWIR
- the operational features required by the mission objective (wind, cloud/aerosol, altimetry, trace gases).

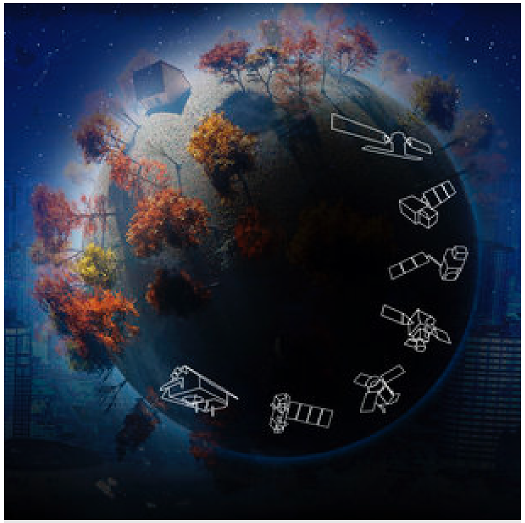
The colour code, is as follows (NOT IN TERMS OF PRIORITY):

1. Doppler lidar, for clear-air wind profile and aerosol; side pointing, along-view measurement.
2. Backscatter lidar, for aerosol profiling and atmospheric discontinuities (cloud top, heights of tropopause and PBL); nadir pointing.
3. Lidar altimeter, mainly for sea-ice boundary and thickness (but also for land topography); nadir pointing.
4. Differential Absorption Lidar (DIAL), for high-vertical-resolution profiles of a few species (e.g., CO2, CH4) by exploiting wavelengths centred on an absorption line and a side window; nadir pointing.

Rating	Type of Instrument	Instruments
1	18. Space lidar	ALADIN 3D-Winds Lidar
2	18. Space lidar	ATLID CALIOP ACE Lidar CATS
3	18. Space lidar	VCL
3	18. Space lidar	ATLAS GLAS
4	18. Space lidar	CO2 lidar
4	18. Space lidar	O3 lidar
4	18. Space lidar	IPDA lidar

OVERVIEW

ESA is developing a new family of missions called Sentinels specifically for the operational needs of the Copernicus programme.



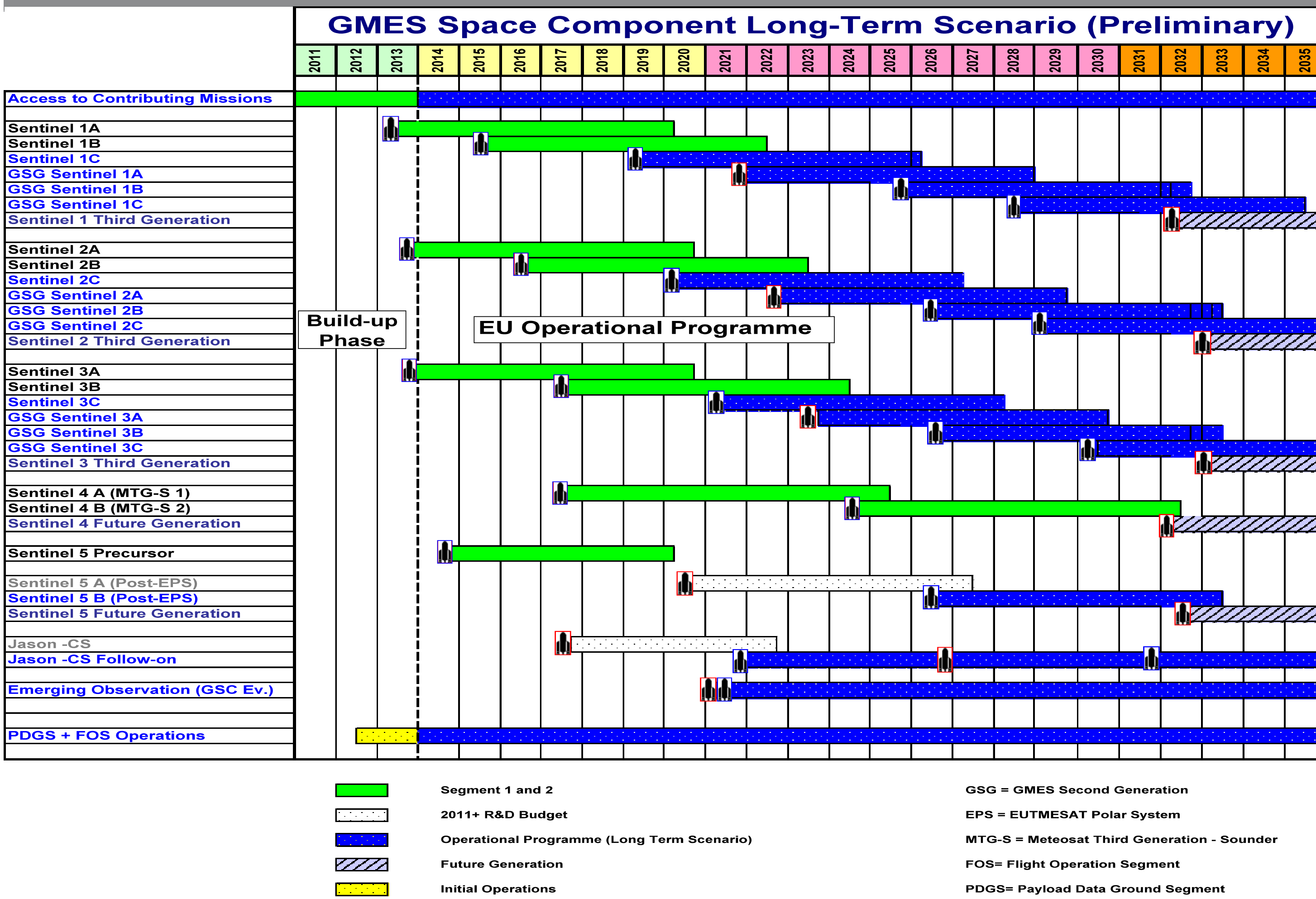
Sentinel family

Each Sentinel mission is based on a constellation of two satellites to fulfil revisit and coverage requirements, providing robust datasets for Copernicus Services.

These missions carry a range of technologies, such as radar and multi-spectral imaging instruments for land, ocean and atmospheric monitoring:

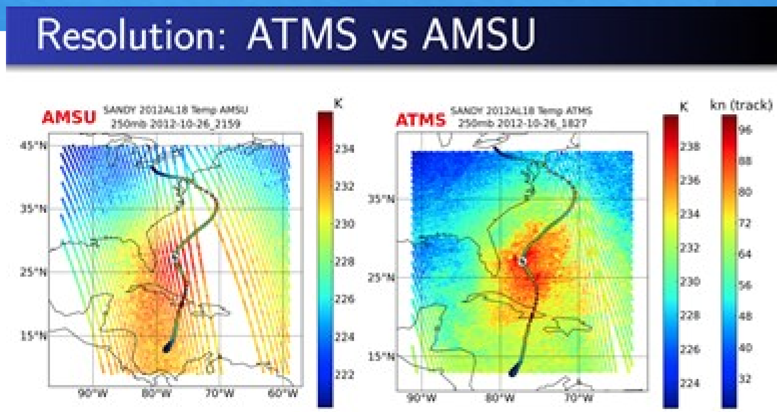
- **Sentinel-1** is a polar-orbiting, all-weather, day-and-night radar imaging mission for land and ocean services. The first Sentinel-1 satellite was launched on a Soyuz rocket from Europe's Spaceport in French Guiana on 3 April 2014.
- **Sentinel-2** is a polar-orbiting, multispectral high-resolution imaging mission for land monitoring to provide, for example, imagery of vegetation, soil and water cover, inland waterways and coastal areas. Sentinel-2 will also deliver information for emergency services.
- **Sentinel-3** is a multi-instrument mission to measure sea-surface topography, sea- and land-surface temperature, ocean colour and land colour with high-end accuracy and reliability. The mission will support ocean forecasting systems, as well as environmental and climate monitoring.
- **Sentinel-4** is a payload devoted to atmospheric monitoring that will be embarked upon a Meteosat Third Generation-Sounder (MTG-S) satellite in geostationary orbit.
- **Sentinel-5** is a payload that will monitor the atmosphere from polar orbit aboard a MetOp Second Generation satellite.
- **Sentinel-5 Precursor** satellite mission is being developed to reduce data gaps between Envisat, in particular the Sciamachy instrument, and the launch of Sentinel-5. This mission will be dedicated to atmospheric monitoring.
- **Sentinel-6** carries a radar altimeter to measure global sea-surface height, primarily for operational oceanography and for climate studies.

GMES Space Component Long Term Scenario (Launch dates are indicative)



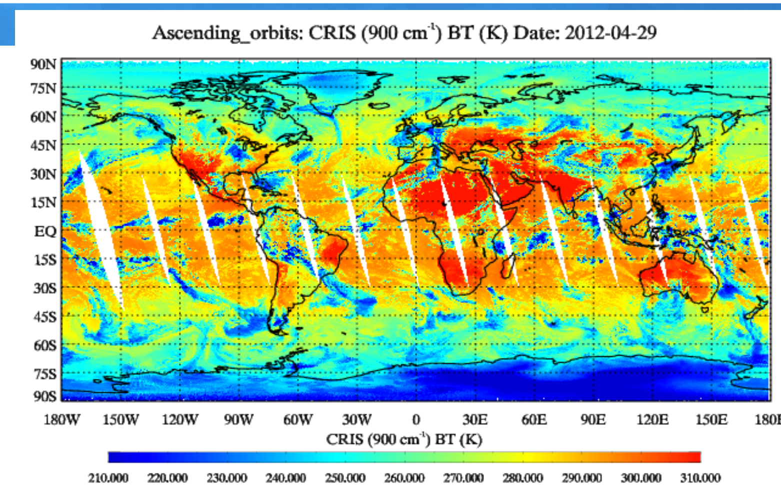
JPSS Next Generation Instruments

Advanced Technology Microwave Sounder



Higher resolution, wider swath, smaller gaps

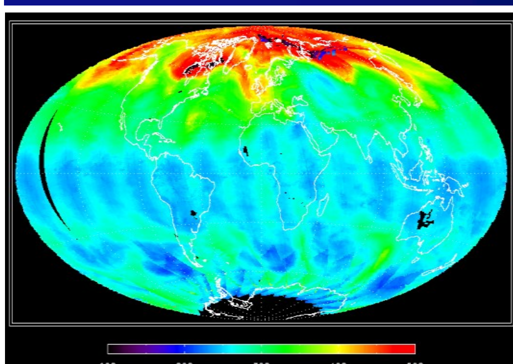
Cross-track Infrared Sounder

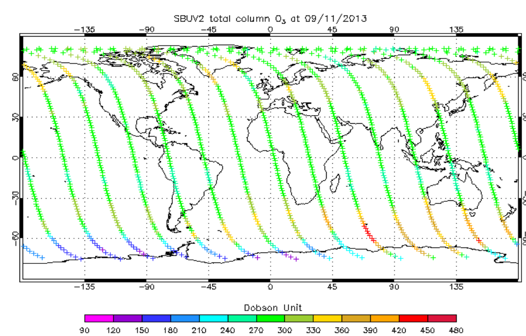


6x more vertical resolving power

Ozone Mapping Profiler Suite

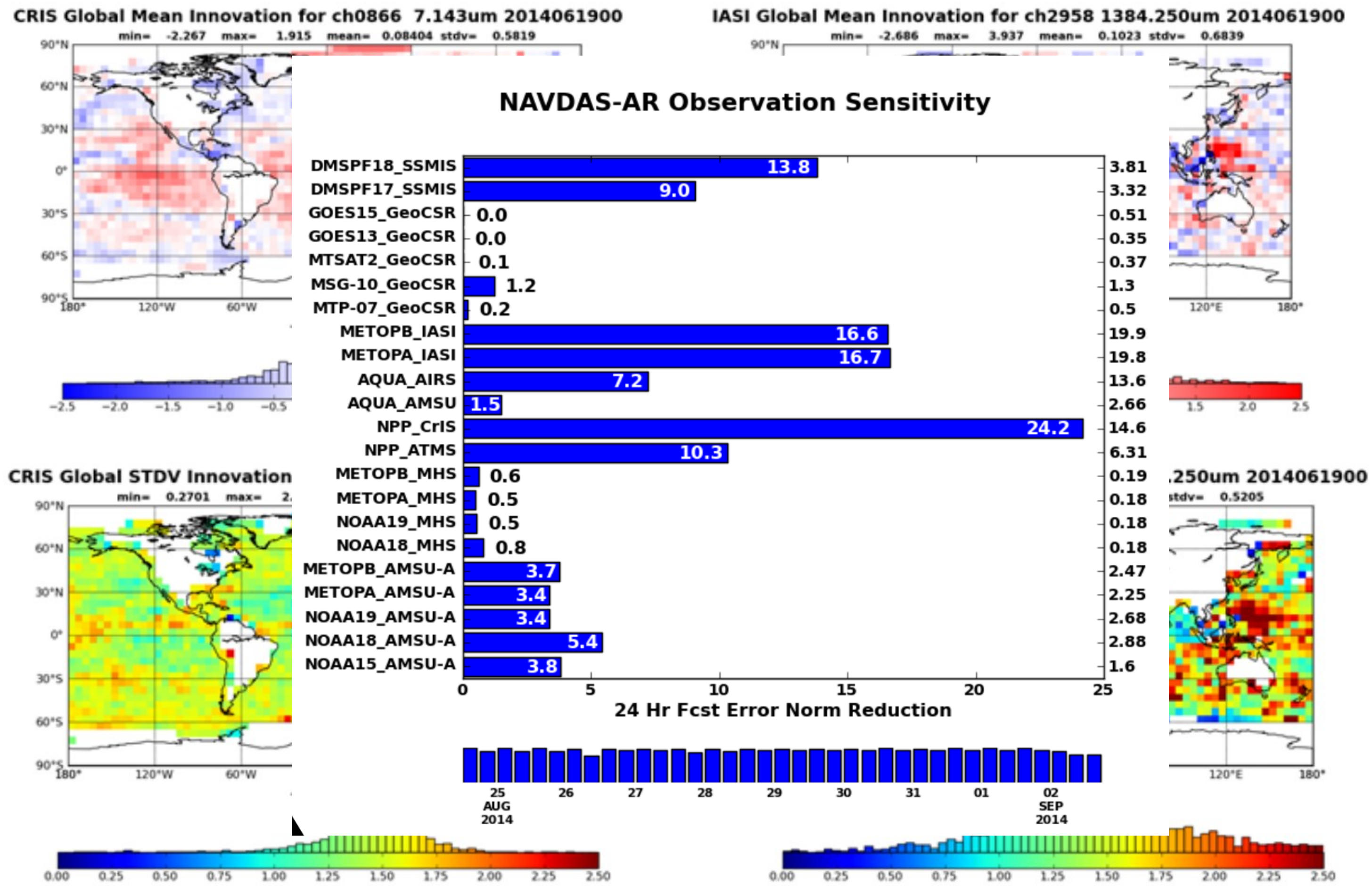
Resolution: OMPS vs SBVU/2



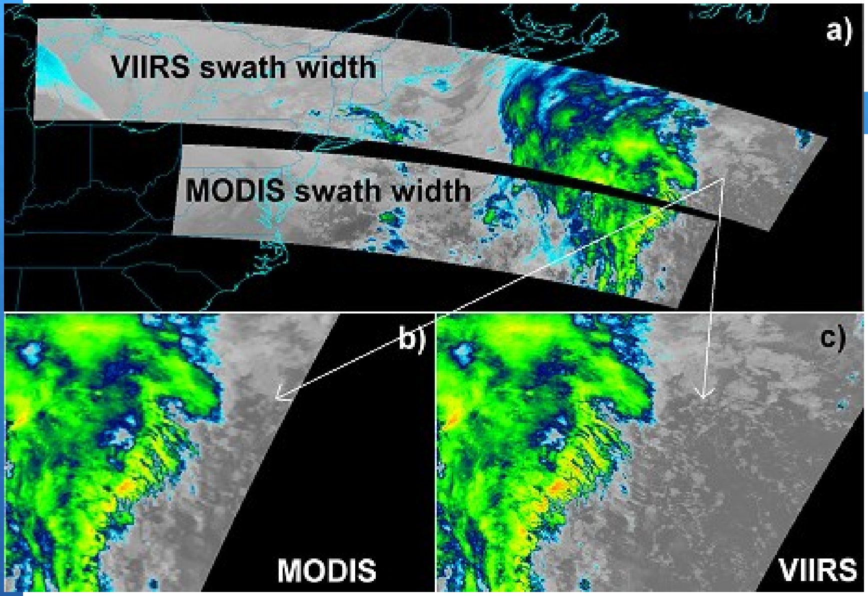


Provides global coverage ozone monitoring

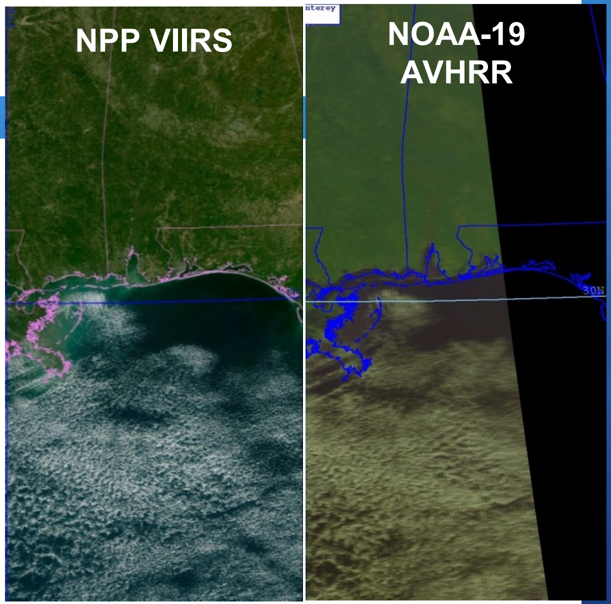
Source: Ben Ruston (Personal Comm.)

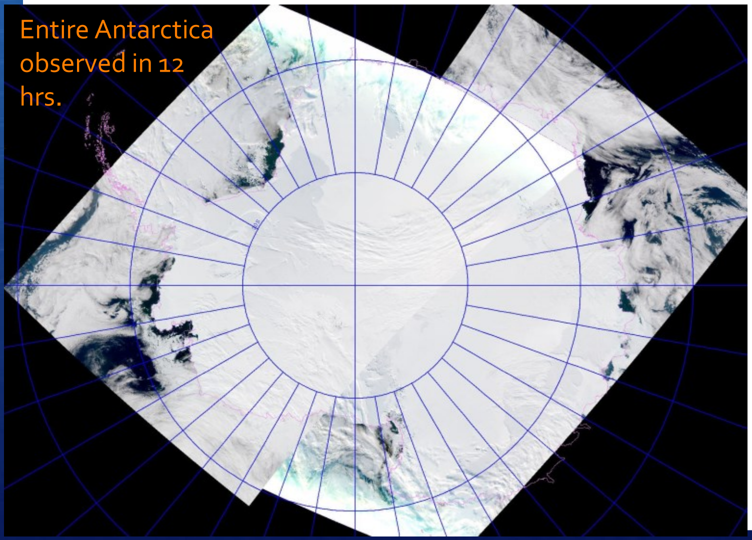


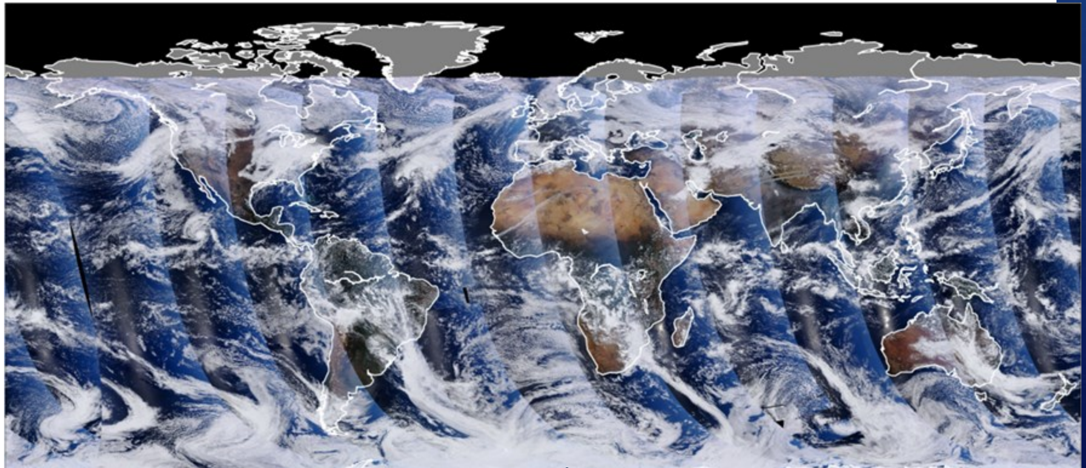
JPSS Next Generation Instruments



The Visible Infrared Imaging Radiometer Suite offers more spectral bands, higher resolution, wider swath and greater accuracy, resulting in a large number of products.

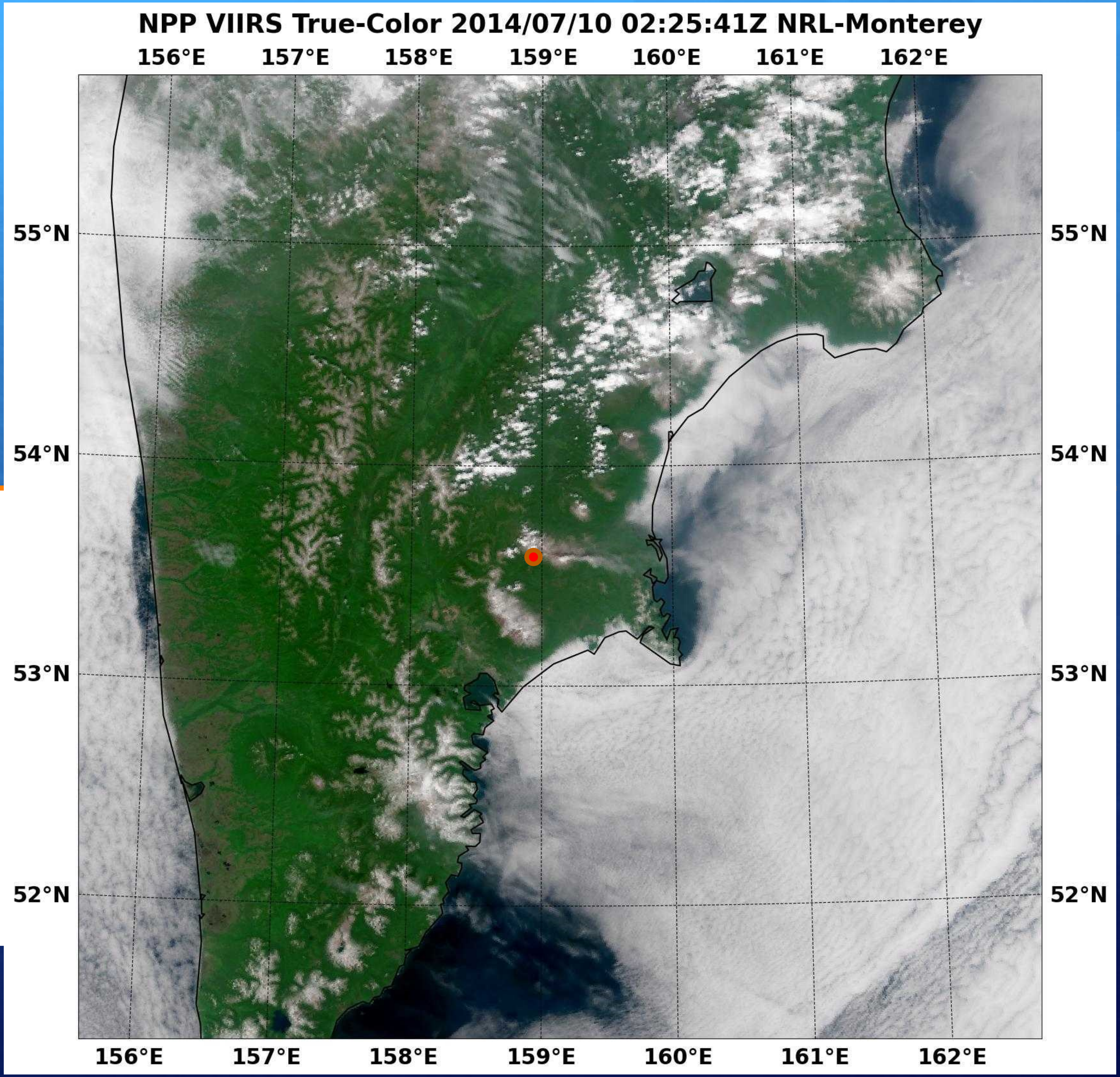




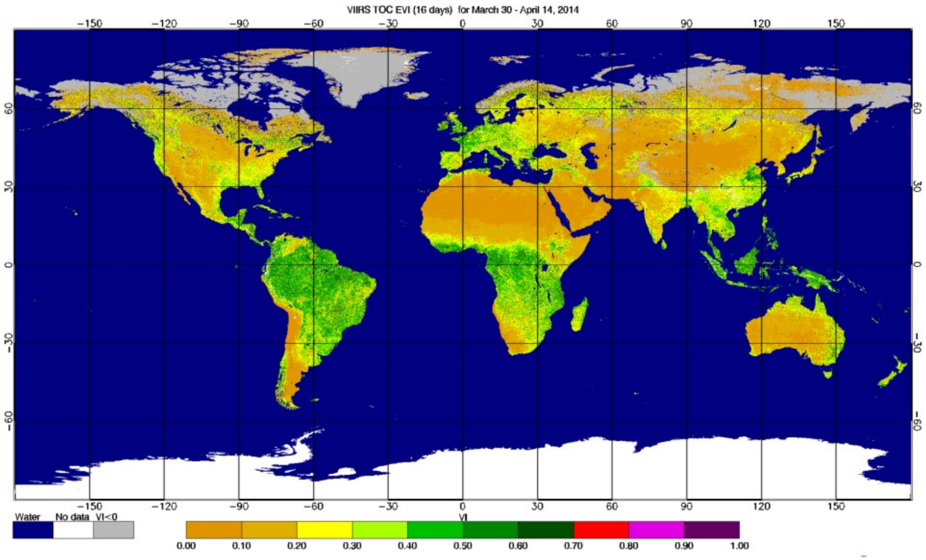


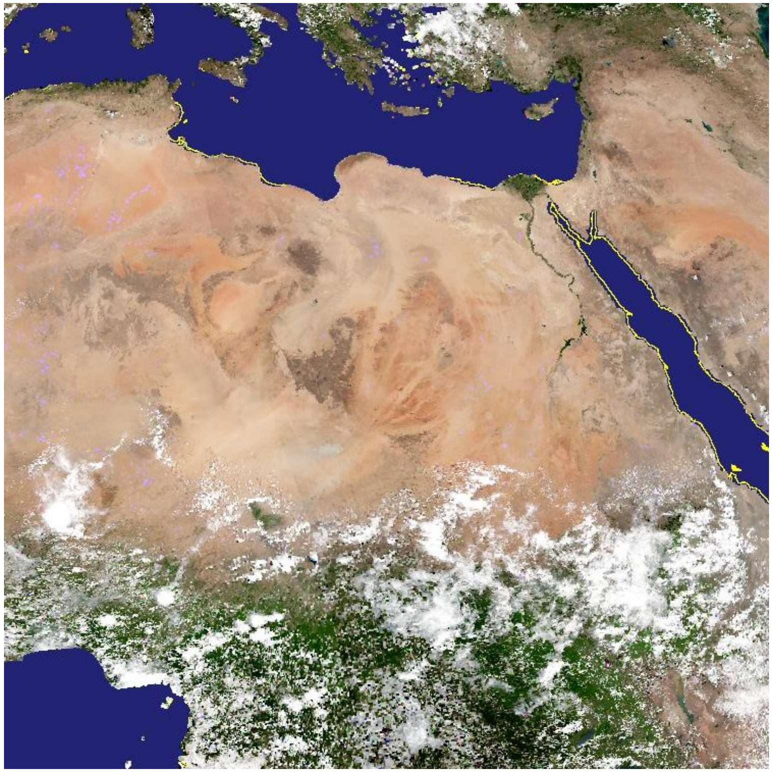
VIIRS RGB (True Color), 11-22-2011
R: M05 (0.672 μm), G: M04 (0.555 μm), B: M02 (0.445 μm)

Comparing MODIS (250m) to VIIRS (375m) Edge of Scan

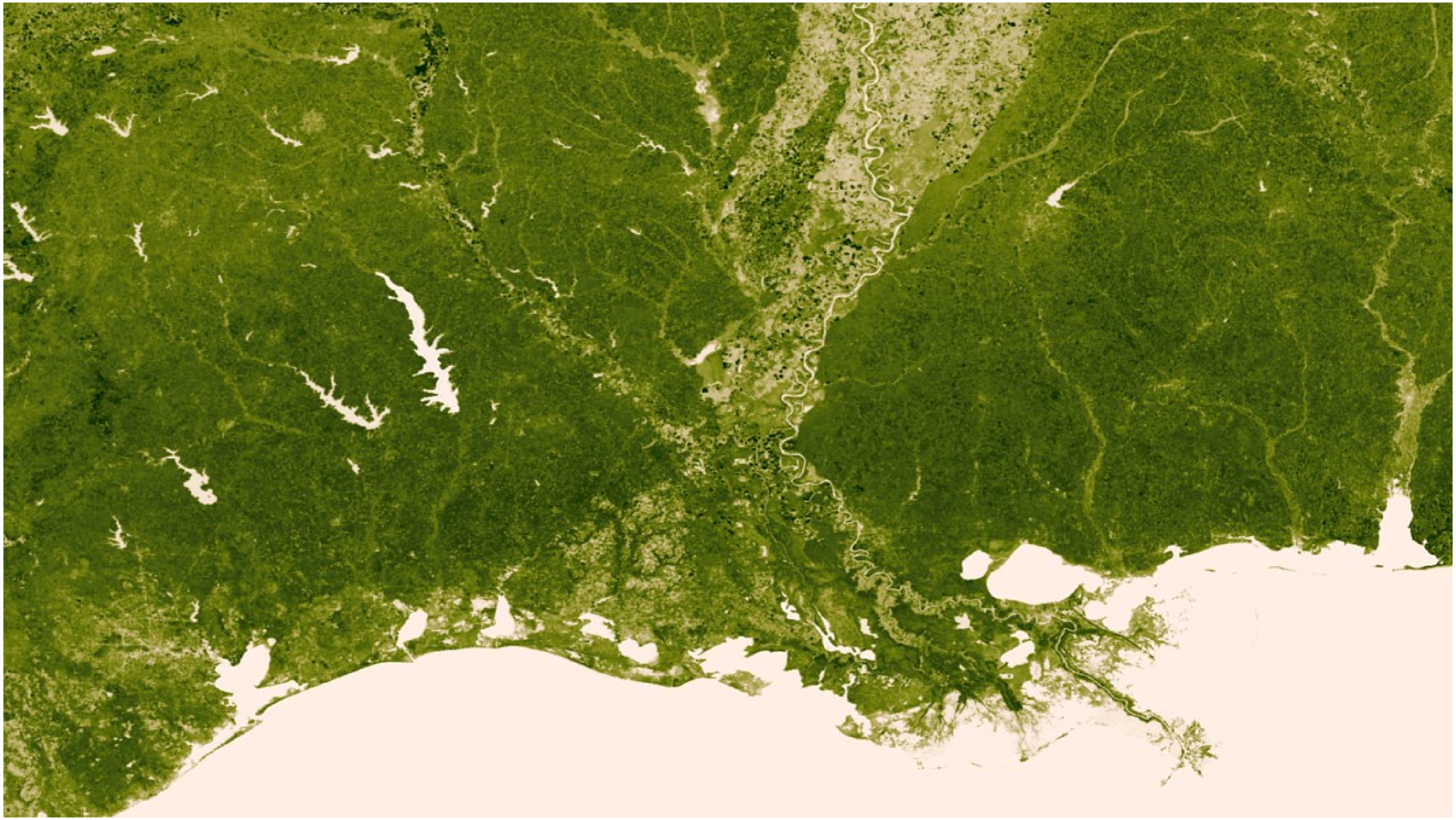


Top of Canopy Vegetation Index and surface reflectance

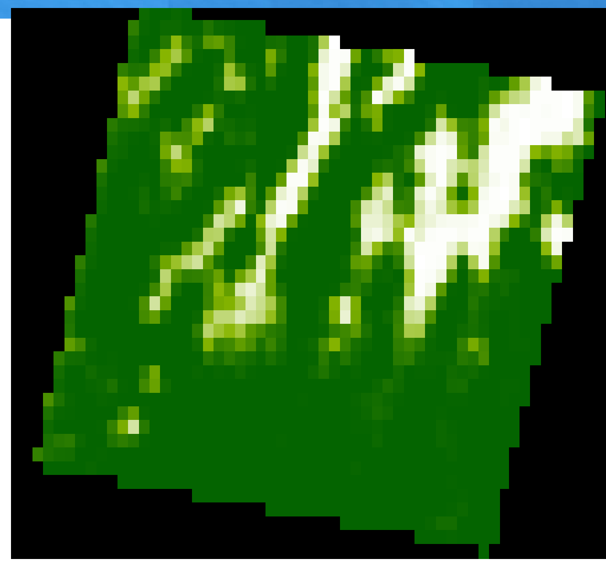


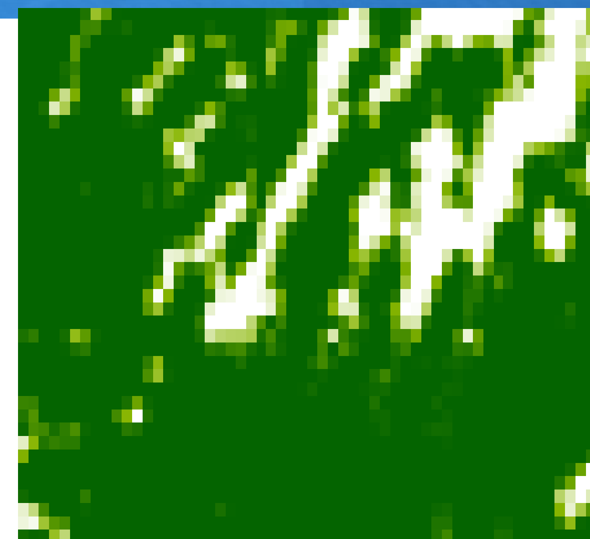


Vegetation Index - 375M resolution



VIIRS Fractional Snow example (375 meters)





Location of Landsat scene

true

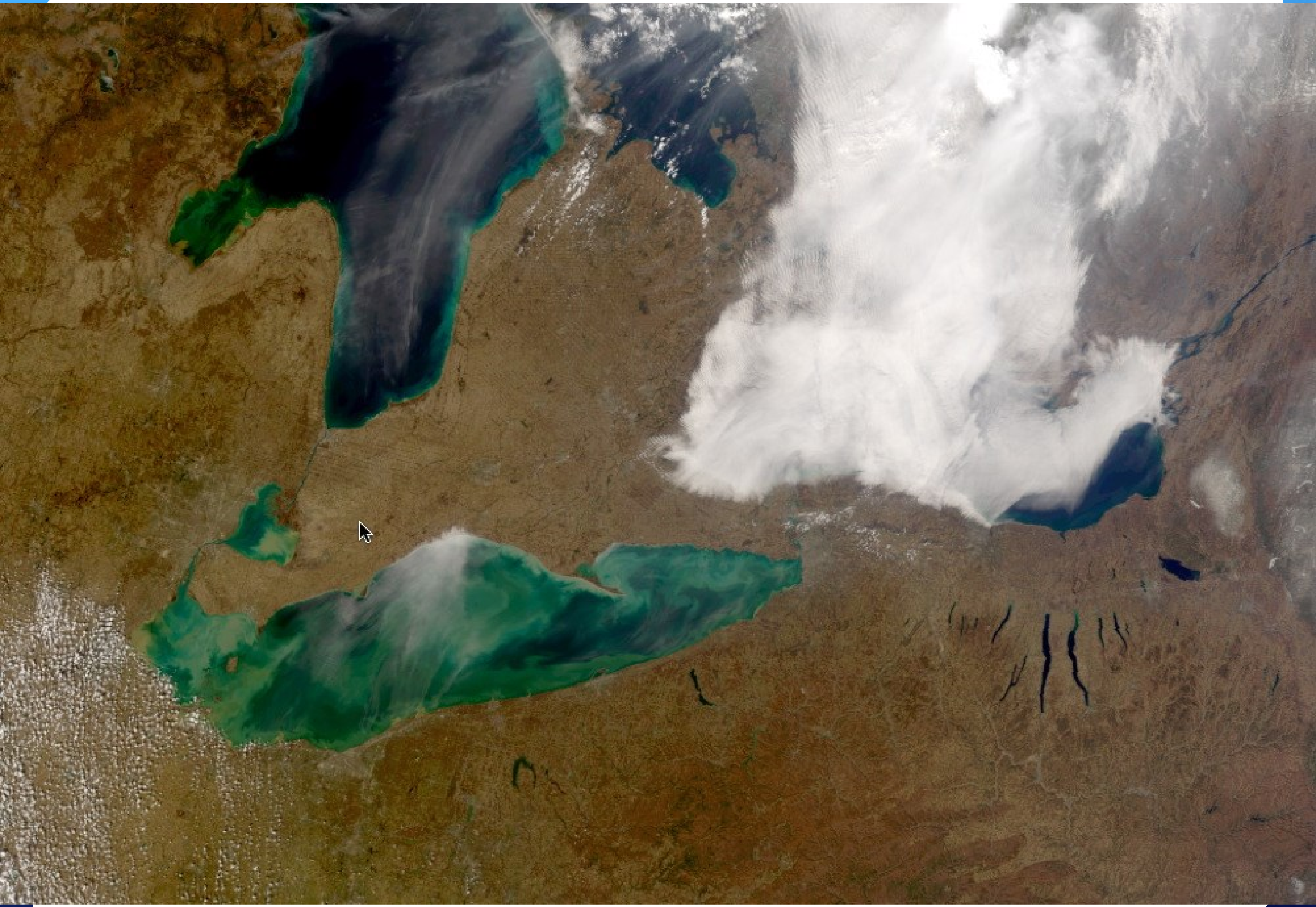
Landsat averaged to VIIRS

VIIRS fraction

on 02/03 (path - 41, row – 33)

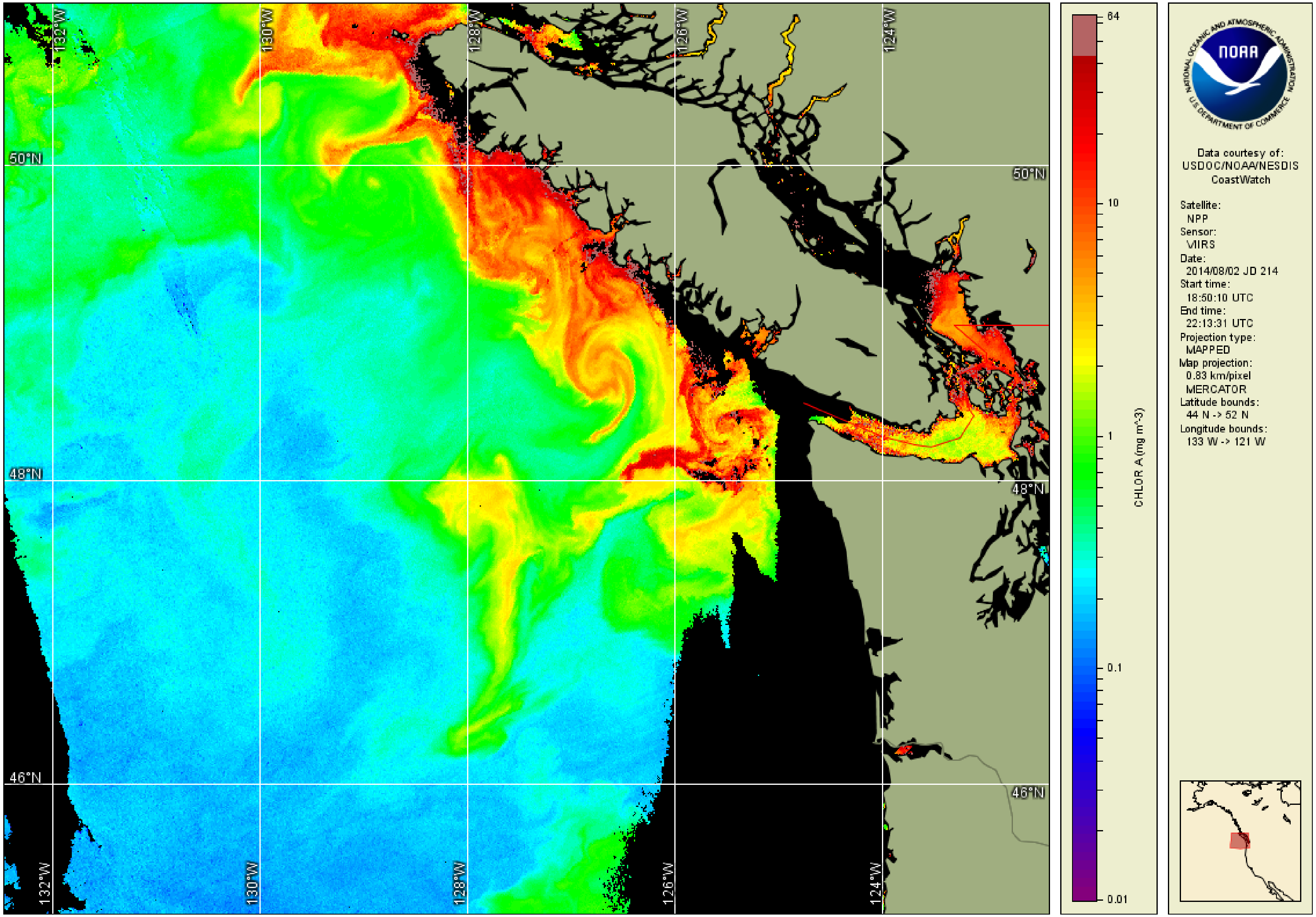
0  1

snow fraction palette



Chlorophyll-a

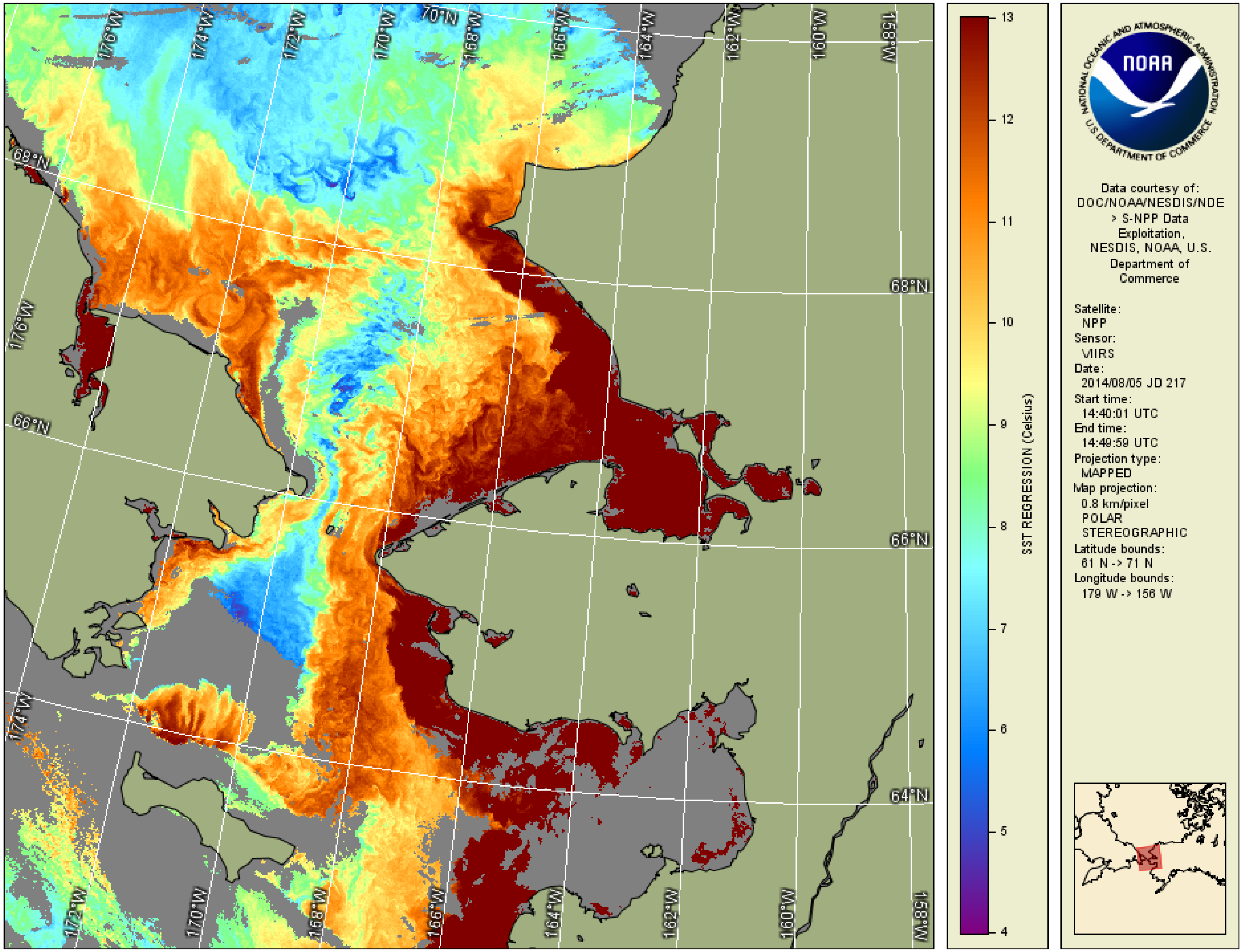
VIIRS, August 2, 2014



True Color – Baltic Sea

Bering Strait

VIIRS ACSPO SST



Summary

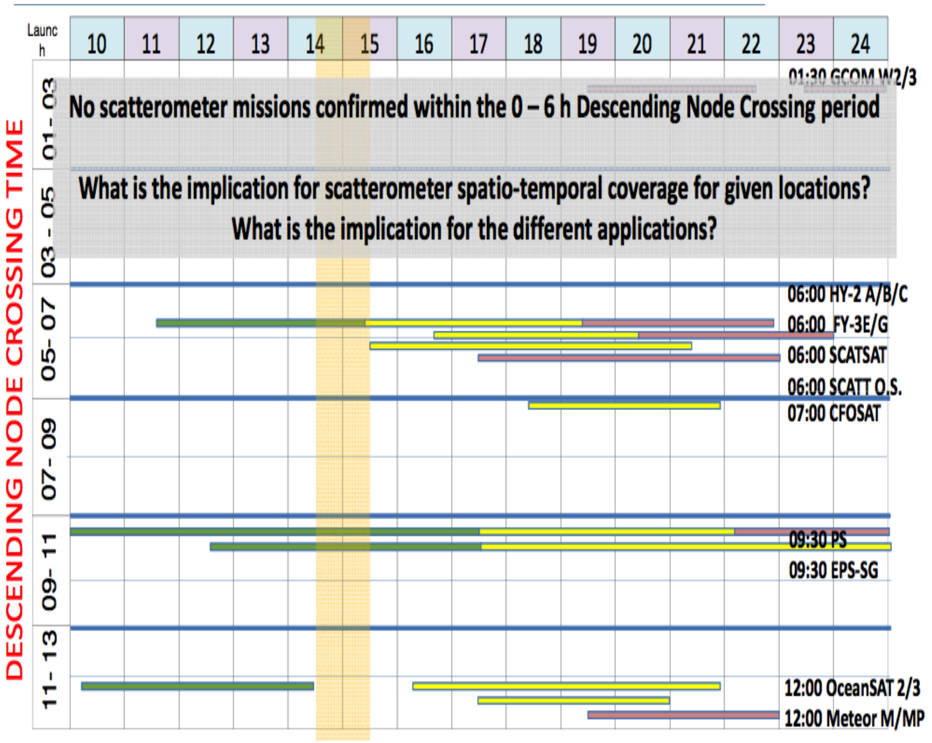
- Hyperspectral IR and Microwave Soundings will be in very good shape.
  - JPSS – two gaps from a failure policy
  - JPS (EUMETSAT and NOAA) provides long-term robustness in mid morning and early afternoon for decades.
  - Important CMA contribution in early morning orbit.
  - Open access critical – use of GTS, Improved Latency through expanded RARS effort.
  - Need NWP community to demonstrate impact, GSICS to demonstrate instrument quality.
  - Hyperspectral IR on EUMETSAT and CMA Geostationary satellites
  - Need to key an eye on long-life rated satellites for sudden gap situation

Summary

- Atmospheric Motion Vectors (AMVs) in very good shape.
  - Advanced geostationary imagers will be common (14+ channels)
  - Geostationary sounders (EUMETSAT, CMA) will provide much improved AMVs – better vertical sampling.
  - Important to advocate water vapor channel for NOAA VIIRS

Summary

- Scatterometers in poor shape
  - EUMETSAT follow-on to ASCAT (mid morning)
  - HY2 series provides early morning – but no real-time access
  - CMA planning for early morning Scatterometers
  - OceanSat 2/3 in noon orbit
  - Need coverage in mid afternoon orbit
  - Real-time access must be addressed



Summary

- GPS RO in precarious shape
  - But approval for COSMIC2 (6+6) would solve most issues
  - 16000 soundings should be achievable with COSMIC2
  - Need to demonstrate better impact in NWP models – use troposphere information
  - Real-time access critical

Instrument	Satellite	# of obs/ day	years	Agency
Radiomet	METEOR-3M (2 sats)	~1300	2020-2030	Roshydromet /Roscomos
RO	EPSG-A1/A2	~1300	2021 - 2042	EUMETSAT
GNOS	FY3C+ (2 sats)	~1300	2014-2020's	CMA
COSMIC-2	6 equatorial satellites	~4500	2016 - 2025	NOAA, NASA, DoD, Taiwan
JASON-CS	JASON	~2000	2018-2025	NOAA, NASA,EUMETSAT, ESA, CNES

Summary

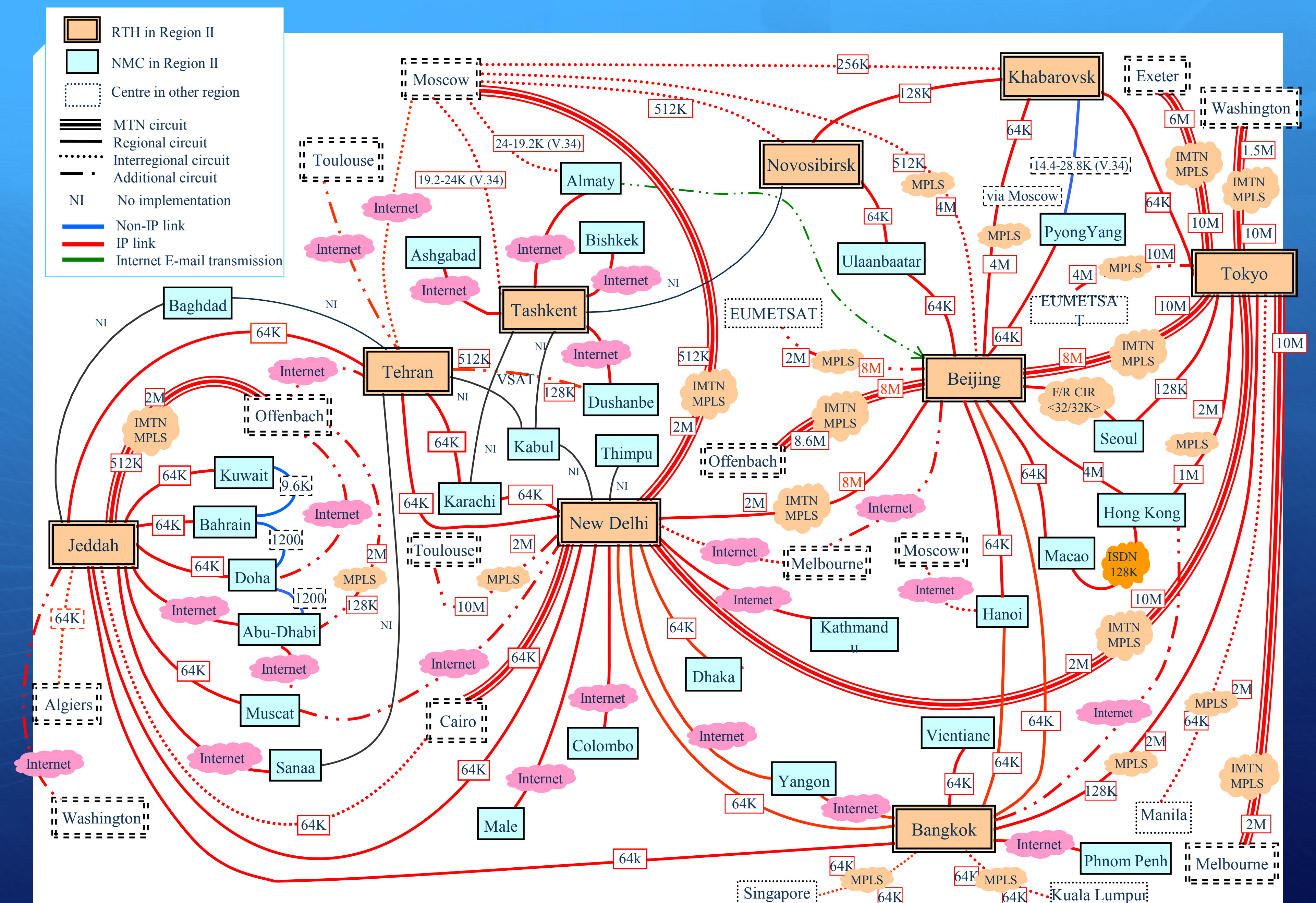
- MWI in poor shape.
  - Mid morning orbit – EPS-SG 2020's to 2040's
  - Uncertainty of follow-on to GCOM-W1 in afternoon orbit
  - CMA in mid morning and early afternoon.
  - Need to find out if CMA will have MWI in early morning orbit
  - Likely US DoD in early morning orbit
  - Russia in mid morning and early afternoon
  - But real-time access is important.
  - From current and real-time perspective – important to get commitment from DoD follow-on and GCOM-W follow-on

Summary

- Visible and Near Infrared Imager in very good shape.
  - Advanced geostationary imagers will be common (14+ channels)
  - Polar orbiters – EUMETSAT (MetImage) and JPSS (VIIRS)
  - CMA in the early morning orbit, mid morning (short term), afternoon orbit.
    - Dose of orbital parameter analysis may help to achieve high refresh over the poles
  - Russia – mid morning and early afternoon

Final thoughts - data access

- Real-time data access to secured data is paramount
- Low latency is critical and needs to be achieved by at least two polar (Arctic and Antarctic) ground stations. < 60 mins
- Direct readout via RARS via GTS
- Global data must be added to GTS by all space agencies.
  - Critical for China to do this.
- TDRSS – satellite to satellite can reduce latency to 5 minutes
- Need updated WMO implementation plan to address better and faster access



Regional Meteorological Telecommunication Network for Region II (Asia)

Current status as of 26 September 2012

ITSC-19, RARS Technical Sub-group