A Gap Analysis for Future Missions Contributing to Flood Measurements

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02/13/12
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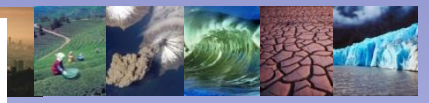
Background

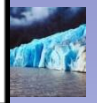
- Originally, disasters floods analysis was to be solely based on measurements that are used to create floods products
- Similar to the CO2 and CH4 approaches but the extensive measurement list made the task exhaustive
  - CO2 and CH4 took into account measurement accuracy, spatial and vertical resolution
  - CO2 and CH4 analysis was very detailed and considered many parameters that required extensive research
- In June, new approach to gap analysis that based the gaps on instrument type
- In September a preliminary analysis was shown that was incomplete due to insufficient repeat cycle and spatial resolution data
- Now showing that same analysis which is complete with the data gaps filled

Disasters SBA Team Instrument Type Rqmts



- Optical imagery
  - Very high resolution panchromatic or multispectral (1 m or less to 2m)
  - High resolution multispectral (2-15m)
  - Medium resolution multispectral (15-30m)
- Hyperspectral (medium to high resolution)(5-30m)
- SAR imagery (specify band – L, C or X)
  - Very high resolution (1-3m)
  - High resolution (3-16m)
  - Medium to low resolution (30, 50 or 100m)
- Revisit
- Data latency
- Imaging time/data volume (SAR only)

Disasters SBA Team Measurement Rqmts



Phase Requirements	Mitigation	Warning	Response	Recovery
Target	Topography Hydrological models Historical atlas of floods Flood models/simulations New infrastructure, houses Land-use classification Monitoring of dikes and dams Tropical cyclone seasonal predictive models/simulations Monitoring sea surface temps Monitoring sea-level rise	Precipitation Water level (rivers, lakes) Weather forecast Soil moisture Snow-water equivalent Signs of catastrophic infra failure Signs of active or high tropical cyclone activity Sea-level Signs of coastal erosion and inundation	Water level (rivers, lakes) Extent of flood Status of critical infrastructure Weather forecast Status of coastal infrastructure Predictive model simulations for rising sea level effects	Status of critical infrastructure Damage assessment Flooded areas
Revisit	Monthly (models during season) 1 to 3 years (imagery) 5 to 10 yrs (topography)	Daily or better during high risk period	Daily in early morning; twice daily if possible	Weekly (major floods) for several weeks to several months
Timeliness	Weeks	Hours	Hours (2-4 max)	1 day

Approach to the Floods Gap Analysis

- Gap analysis of key instrument types for imagery requirements
  - High resolution optical imagers
  - Multi-spectral radiometers (vis/IR)
  - Imaging Microwave Radar (Synthetic aperture radars)
  - Imaging multi-spectral radiometers (passive microwave)
- Downselect with revisit and latency requirements; latency data not available in the database
- Do an instrument level detailed gap analysis on the top priority measurements that are most at risk as identified from some preliminary analysis

Instrument Types Analysis, High Res Optical Imagers

- Desktop database query that refines list by revisit; partial list shown
- Requirements are as follows: mitigation phase – monthly, warning phase – daily, response, daily or twice daily, recovery - weekly

instrumentNameShort	instrumentSpatialResolutionBest	instrumentAccuracyDescription	missionNameShort	launchDate	eolDate	repeatCycle
MSI	6.5	2-3%	RapidEye	29-Aug-08	30-Aug-15	1
Event Imaging Spectrometer from GEO (GeoCape)	250		GEO-CAPE	01-Jan-20	01-Jan-23	1
NigeriaSat Medium and High Resolution	2.5	35-45m	NigeriaSat-2	17-Aug-11	17-Aug-18	4
PAN (Cartosat-2A/2B)	1		CARTOSAT-2A	28-Apr-08	28-Apr-13	5
SLIM-6-22	22	S/N 150:1 @ target albedo of 0.1.	UK-DMC2	29-Jul-09	29-Jul-14	5
PAN (Cartosat-2A/2B)	1		CARTOSAT-2B	12-Jul-10	01-Jul-15	5
MSS	8.2	8 bits	Sich-2	17-Aug-11	17-Aug-15	5
PAN (Cartosat-3/3A)	0.3		CARTOSAT-3	01-Jul-15	01-Jul-20	5
Geoton-L1	1		Resurs P N1	01-May-12	01-May-17	6
Geoton-L1	1		Resurs P N2	31-Dec-13	31-Dec-18	6
HRTC	35		SAC-C	21-Nov-00	01-Jan-12	9

September Analysis - Preliminary Instrument Types Analysis, High Res Optical Imagers

- After considering the revisit requirements, there are gaps for this instrument type
- Need to account for spatial resolution
- Only considers those instruments in the DB with a repeat cycle number; if it was blank it was not considered. Results not completely accurate

Instrument Type	SpatialResolution	mission	repeat Cycle	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
High resolution optical imagers	Panchromatic: 61 centimeter (2 ft) Ground Sample Distance (GSD) at nadir, Multispectral: 2.4 meter (8 ft) GSD at nadir	QuickBird-2	1																
	6.5 m	RapidEye	1																
	2.5 m	CARTOSAT-1	5																
	22 m	UK-DMC2	5																
	1 m	CARTOSAT-2B	5																
	7.8 m	Sich-2	5																
	2.5 PAN, 5m multispectral (red blue green,NIR), 32 m multispectral (red, green, NIR)	NigeriaSat-2	4																
	250 m spatial resolution, 20-50 nm (MODIS-like) spectral bands	GEO-CAPE	1																
Total High Resolution Optical Imagers meeting the weekly revisit requirement				4	7	7	5	5	5	3	1	1	0	0	1	1	1	1	0
TotalHigh Resolution Optical Imagers meeting the daily revisit requirement				2	2	2	1	1	1	1	0	0	0	0	1	1	1	1	0

Instrument Types Analysis, High Res Optical Imagers

- After considering the revisit requirements, there are few instruments in 2019 and 2020 with a weekly repeat cycle
- Need to account for spatial resolution

nstrument Typ	patialResolutic	mission	repeat Cycle	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
	6.5 m	RapidEye	1													
	22 m	UK-DMC2	5													
	1m	CARTOSAT-2A	5													
	22m	UK-DMC2	5													
	1 m	CARTOSAT-2B	5													
	7.8 m	Sich-2	5													
	2.5 PAN, 5m multispectral (red blue green,NIR), 32 m multispectral (red, green, NIR)	NigeriaSat-2	4													
	1m	GEOTON-L1	6													
	.3m	CARTOSAT-3	5													
	250 m spatial resolution, 20-50 nm (MODIS-like) spectral bands	GEO-CAPE	1													
Total High Resolution Optical Imagers meeting the weekly revisit requirement				8	8	7	5	3	3	2	1	2	1	1	1	0
TotalHigh Resolution Optical Imagers meeting the daily revisit requirement				1	1	1	1	0	0	0	0	1	1	1	1	0

Preliminary Instrument Types Analysis, Imaging Multi-Spectral Radiometer, vis/IR

instrumentNameShort	instrumentSpatialResolutionBest	instrumentAccuracyDescription	missionNameShort	launchDate	eolDate	repeatCycle
EPIC	8000		DSCOVR	01-Jul-14	01-Jul-16	1
IR Correlation Radiometer (GeoCape)	7000	CO precision: 1 x 10^17 cm^ (-2)	GEO-CAPE	01-Jan-20	01-Jan-23	1
PCWMP	500	Cal/Val requirements currently being developed	PCW-1	01-Sep-16	01-Mar-24	1
PCWMP	500	Cal/Val requirements currently being developed	PCW-2	01-Dec-16	01-Jun-24	1
VSC	5.3		VENUS	31-Jan-13	31-Jan-16	2
TIR (Oceansat-3/3A)	1000		OCEANSAT-3	01-Oct-14	01-Oct-19	2
TIR (Oceansat-3/3A)	1000		OCEANSAT-3A	01-Jan-18	01-Jan-23	2
TANSO-CAI	500		GOSAT	23-Jan-09	22-Jan-14	3
SGLI	250		GCOM-C2	01-Feb-18	01-Feb-23	3
SGLI	250		GCOM-C3	01-Feb-22	01-Feb-27	3
OLS	560		DMSP F-16	18-Oct-03	01-Oct-12	4
OLS	560		DMSP F-15	12-Dec-99	01-May-13	4
OLS	560		DMSP F-17	04-Nov-06	01-Jun-13	4
OLS	560		DMSP F-18	18-Oct-09	01-Apr-14	4
RASAT VIS Panchromatic	7.5		RASAT	17-Aug-11	17-Aug-14	4
RASAT VIS Multispectral	15		RASAT	17-Aug-11	17-Aug-14	4
AWIFS	55	10 bit data	AWIFSSAT	01-Jan-12	01-Jan-16	4
OLS	560		DMSP F-19	01-Oct-12	01-Oct-17	4
OLS	560		DMSP F-20	05-Jun-14	01-Jun-19	4
MERSI	250	0.25~1.0km	FY-3B	05-Nov-10	31-Dec-13	5

Only partial list…

September Preliminary Instrument Types Analysis, Imaging Multi-Spectral Radiometer, vis/IR Summary

Instrument Type	SpatialResolution	mission	repeat Cycle	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Imaging multi-spectral radiometers (vis/IR)	0.5 km (0.380, 0.678, 0.870 µm bands), 1.5 km (1.62 µm band)	GOSAT	3																
	46.0 m	Sich-2	5																
	15 m	RASAT	4																
	250 m	HY-1D	7																
	100 km	SAC-D/Aquarius	7																
	250 m	HY-1C	7																
	55 m	AWiFSSAT	4																
	36 m or 18 m depending on wavebands selected.	PROBA	7																
	5.3 m spatial resolution with 27 km swath	VENUS	2																
	20 km, 17 km, 10 km	OCEANSAT-3	2																
	Band dependent, varies from 0.5 km GSD (goal) for some of the VNIR bands to 2 km GSD for TIR bands.	PCW-1	1																
	Band dependent, varies from 0.5 km GSD (goal) for some of the VNIR bands to 2 km GSD for TIR bands.	PCW-2	1																
	7 km horizontal spatial resolution, 2-3 layers in vertical resolution; < 0.2 um spectral resolution.	GEO-CAPE	1																
Total Imaging multi-spectral radiometers (vis/IR) meeting the weekly revisit requirement				1	4	6	8	9	7	5	6	4	3	3	4	4	4	3	1
Total Imaging multi-spectral radiometers (vis/IR) meeting the daily revisit requirement				0	0	0	0	0	0	0	1	1	1	1	3	3	3	3	1

Final Instrument Types Analysis, Imaging Multi-Spectral Radiometer, vis/IR Summary

Instrument Type	SpatialResolution	mission	repeat Cycle	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Imaging multi-spectral radiometers (vis/IR)	560m	DMSP F-16	4													
	560m	DMSP F-15	4													
	560m	DMSP F-17	4													
	1100m	NOAA-17	5													
	560m	DMSP F-18	4													
	0.5 km (0.380, 0.678, 0.870 µm bands), 1.5 km (1.62 µm band)	GOSAT	3													
	250m	FY-3B	5													
	46.0 m	Sich-2	5													
	15 m	RASAT	4													
	250 m	HY-1D	7													
	100 km	SAC-D/Aquarius	7													
	250 m	HY-1C	7													
	560m	DMSP F-19	4													
	55 m	AWiFSSAT	4													
	36 m or 18 m depending on wavebands selected.	PROBA	7													
	5.3 m spatial resolution with 27 km swath	VENUS	2													
	250m	FY-3C	5													
	1m	Cartosat-2c	5													
	8000m	DSCOVR	1													
	20 km, 17 km, 10 km	OCEANSAT-3	2													
	560m	DMSP F-20	4													
		FY-3D	5													
	Band dependent, varies from 0.5 km GSD (goal) for some of the VNIR bands to 2 km GSD for TIR bands.	PCW-1	1													
	1m	CARTOSAT-2D	5													
		FY-3E	5													
	20 km, 17 km, 10 km	OCEANSAT-3A	2													
	250m	GCOM-C2	3													
		FY-3F	5													
	Band dependent, varies from 0.5 km GSD (goal) for some of the VNIR bands to 2 km GSD for TIR bands.	PCW-2	1													
	7 km horizontal spatial resolution, 2-3 layers in vertical resolution; < 0.2 um spectral resolution.	GEO-CAPE	1													
	30m	FY-3G	5													
	250m	GCOM-C3	3													
Total Imaging multi-spectral radiometers (vis/IR) meeting the weekly				8	17	14	11	13	10	9	9	9	9	9	8	3
Total Imaging multi-spectral radiometers (vis/IR) meeting the daily revisit				0	0	1	1	2	1	1	1	3	3	3	3	1

Final Instrument Types Analysis, SAR

instrumentNameShort	instrumentSpatialResolutionBest	instrumentAccuracyDescription	missionNameShort	launchDate	eolDate	repeatCycle
SAR (MAPSAR)			MAPSAR	03-Dec-15	03-Dec-19	7
X-Band SAR	1		TerraSAR-X	15-Jun-07	31-Dec-13	11
X-Band SAR	1		TanDEM-X	21-Jun-10	31-Dec-15	11
Paz SAR-X	1	"Pixel Localization: Pixel Localization: 50 cm to 8.5 m (1σ) depending of the product selected.	PAZ	15-Nov-12	31-Dec-17	11
X-Band SAR	1		TerraSAR-X2	31-Dec-15	31-Dec-22	11
SAR (RISAT)	3		RISAT-1	15-Feb-12	15-Feb-16	12
SAR (RISAT)	3		RISAT-1A	01-Sep-15	01-Sep-19	12
C-Band SAR	9	NESZ: -22 dB; PTAR: -25 dB; DTAR: -22 dB; Radiometric accuracy 1 dB (3 sigma); Radiometric stability: 0.5	Sentinel-1 A	30-May-13	30-Aug-20	12
SAR (RCM)	3	Absolute Radiometric Accuracy: +/- 1.0 dB Scansar discontinuities: 0.2 dB	RADARSAT C-1	01-Aug-14	01-Aug-21	12

Only partial list… None meet the weekly revisit require ment

Preliminary Instrument Types Analysis, Imaging Multi-Spectral Radiometer, Passive MW

Committee on Earth Observation Satellites

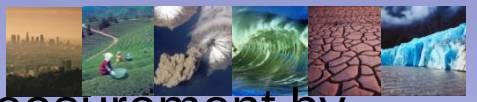
Only partial list…

instrumentNameShort	instrumentSpatialResolutionBest	instrumentAccuracyDescription	missionNameShort	launchDate	eolDate	repeatCycle
MSMR	40	Sea surface temparature: 1.5 K, Sea surface wind speed: 1.5 m/s	IRS-P4	26-May-99	31-Dec-06	2
MSMR	40	Sea surface temparature: 1.5 K, Sea surface wind speed: 1.5 m/s	OCEANSAT-1	26-May-99	31-Dec-10	2
L-band Radiometer (SMAP)			SMAP	29-Oct-14	31-Dec-17	3
AMSR		Sea surface temparature: 0.5 K, sea ice cover: 10%, cloud liquid water: 0.05 kg/m2, precipitation rate: 10%, water vapour: 3.5 kg/m2 through total column, sea surface	ADEOS-II	01-Nov-02	24-Oct-03	4
SSM/I			DMSP F-15	12-Dec-99	01-May-13	4
MWRI			FY-3B	05-Nov-10	31-Dec-13	5
MWRI			FY-3C	31-Dec-13	31-Dec-16	5
MIRAS			FY-3C	31-Dec-13	31-Dec-16	5
MWRI			FY-3D	31-Dec-15	31-Dec-18	5
MIRAS			FY-3D	31-Dec-15	31-Dec-18	5
MIRAS			FY-3E	31-Dec-17	31-Dec-20	5
MWRI			FY-3F	31-Dec-19	31-Dec-22	5

Floods Gap Analysis Next Steps from September

- ✓ Complete the repeat cycle data in the MIM that is missing so all instruments are included
- ✓ Complete the MIM spatial resolution data and filter by this
- ✓ Repeat the analysis
- Latency data is not in the database and will not be included at this time
- Gather SAR imaging time/data volume information; develop requirements on limitation first

Where do we go from here?



- For each of the floods measurements, break down the measurement by instrument type and perform gap analysis
  - Soil moisture, precipitation, vegetation cover, snow cover, snow water equivalent

Mission	Instrument	Resolutions: Spatial Sample Δx (km)	Spatial Swath (km)	Vertical Δz (km)	Temporal Repeat Cycle Δt (hrs/days)	Accuracy: Total Troposphere Column	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Nadir Absorption, Total Troposphere Columns weighted to the Lower Troposphere																							
ENVISAT	SCIAMACHY	30 x 60	960		840 (35 days)	1.5 - 2% [11]																	
GOSAT	TANSO-FTS	10.5	790*		72 (3 days)	0.5 - 1.8%																	
GEO-CAPE	IR Correlation Radiometer	4			12 hours	1%																	
Sentinel-5 Precursor	UVNS	15	2400		27 days	2%																	
Sentinel-5 Post-EPS	UVNS	15	2400		27 days	2%																	
Nadir Emission, Total Troposphere Columns weighted to the Mid-Troposphere and Upper-Troposphere																							
EOS-AQUA	AIRS / AMSU	13	1620		384 (16 days)	1.2 - 1.5 %																	
EOS-AURA	TES	0.5 x 5.0	50		384 (16 days)	0.70%																	
Metop (A,B,C)	IASI	12	2052		12 hours	.9% [10]	5	5	5	5	4	4	3	3	2								
METEOR-M N2	IKFS-2	35	2000		898 (37 days)																		
Limb Viewing, Stratosphere Profiles																							
SCISAT-1	ACE-FTS	500		3	annual	10% in UT, LS 25% in mid-upper strat																	

Example from the Methane report

- Engage VCs or Disaster SBA team experts to provide requirements for each measurement and downselect the instruments