VIIRS Status to Joint MODIS/VIIRS Science Team

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Presentation Outline

- **VIIRS Management Strategies**
  - NDPD organization
  - Structure and Schedule of CV Program
- **VIIRS Sensor performance Comparisons to MODIS**
  - Murphy/Godden Charts
  - Still under study for F1 Program
  - MODIS – VIIRS overlaps in approaches
- **VIIRS Anticipated Caveats**
  - EDU Items
  - F1 Items

VIIRS Management Strategy

Division Organization

and

Structure and Schedule for Calibration and Validation

Use For Government Evaluation Purposes only

NPOESS Data Products Division

May 2008

- Air Force
- NOAA
- Navy
- NASA
- Contractor

Admin Support
S. Snead

Chief
K. St.Germain

Deputy (Vacant)

Sr. Advisor - Operations
C. Hoffman

Sr. Advisor - Science
R. Murphy (1/2)

NOAA Corp 04
J. Adler (On Assignment)

Sr. Engineer
N. Baker

M. Stokes
Program Control

NGST Compliance and Risk Team:
V. Grano
Risk & Coordination: G. Trumbower
Technical Support: West Coast Aerospace

Business Support:
Godin (IPA)

GovtTransfers & MOUs (25)
Contracts COR (6)
Godin (IPA), C. Hoffman, B. Guenther (IPA), V. Grano,

Contract Assoc* J. Moore
Docs and Reporting Vacant

G. Mineart
(SE)

IMs
(Payloads)

Sensor Data Products:
B. Guenther (IPA)

Deputy (Vacant)

Infrastructure:
Capt. V. Gonzalez

Interfaces and Design: J. Zajic
Alg Code and Config: R. Cember, P. Xu
Tool Development: M. Denning, J. Henson, S. Thomas

B. Thomas
(Ground)

VIIRS Lead
Frank DeLuccia

CrIS/ATMS
Gail Bingham

OMPS Lead
Scot Janz

MIS Lead
Dave Kunkee

GFE:
SEM, CERES, ATMS
TSIS (TBD)

(4) VIIRS Sensor Projects

(3) CrIMMS Sensor Projects

(2)OMPS Sensor Projects

(9) MIS Sensor Projects (Payloads)

(2) Projects

G. Mineart
(SE)

M. Ripley,
T. Johnson
(Ground)

User Liasons
(SE)

Environmental Data Products:
C. Hoffman

Deputy
Vacant

Surface & Met : B. Reed
Atmosphere: H. Kilcoyne
Cal/Val Planning: (Vacant)

(15) VIIRS Product Projects

(5) CrIMMS Product Projects

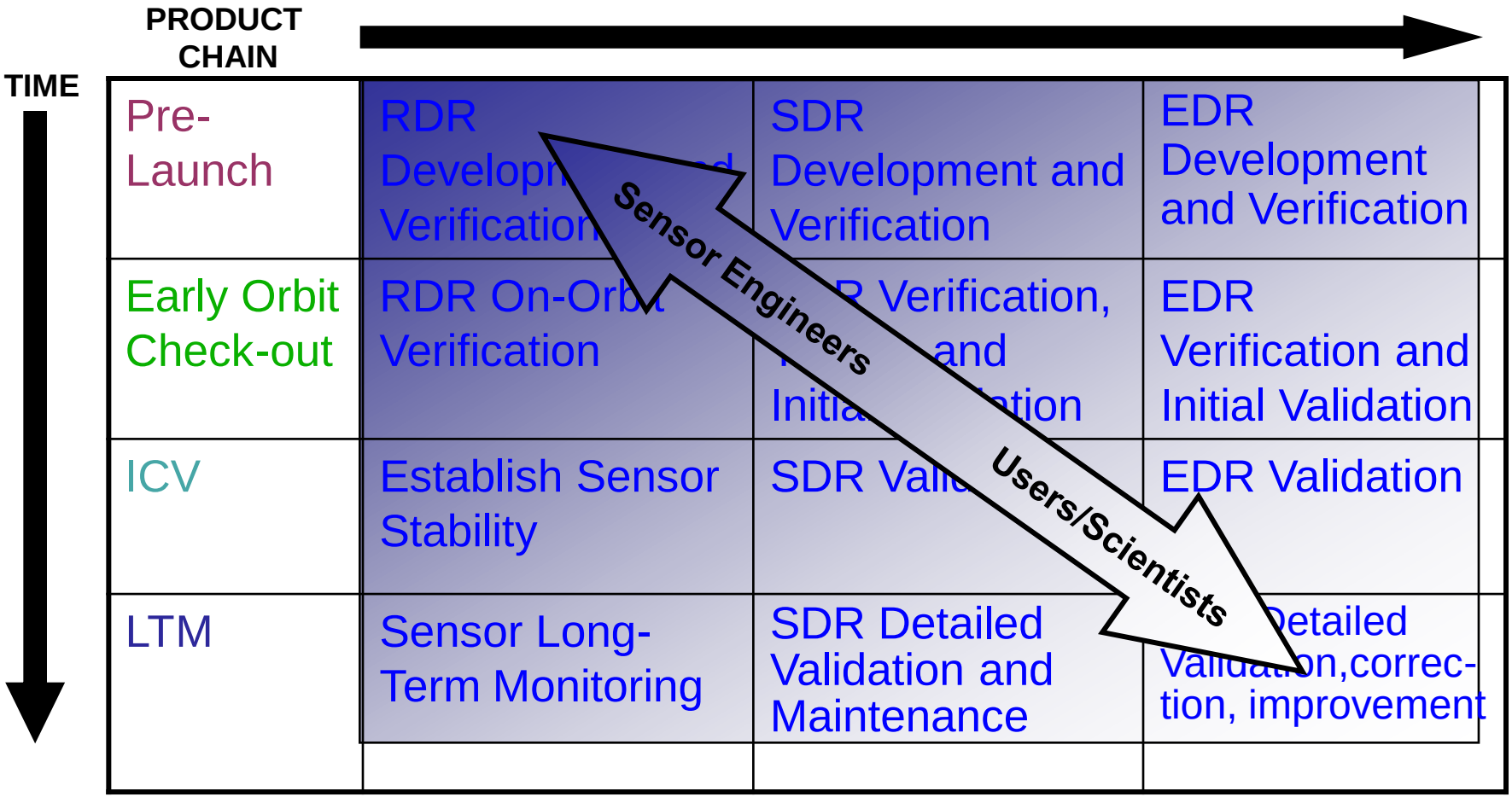
(2)OMPS Product Projects

(1) MIS Product Projects

(2) X-Cutting Cal/Val Projects

Key interfaces with other divisions are identified by dashed boxes

Phases of Cal/Val Evolution of Expertise

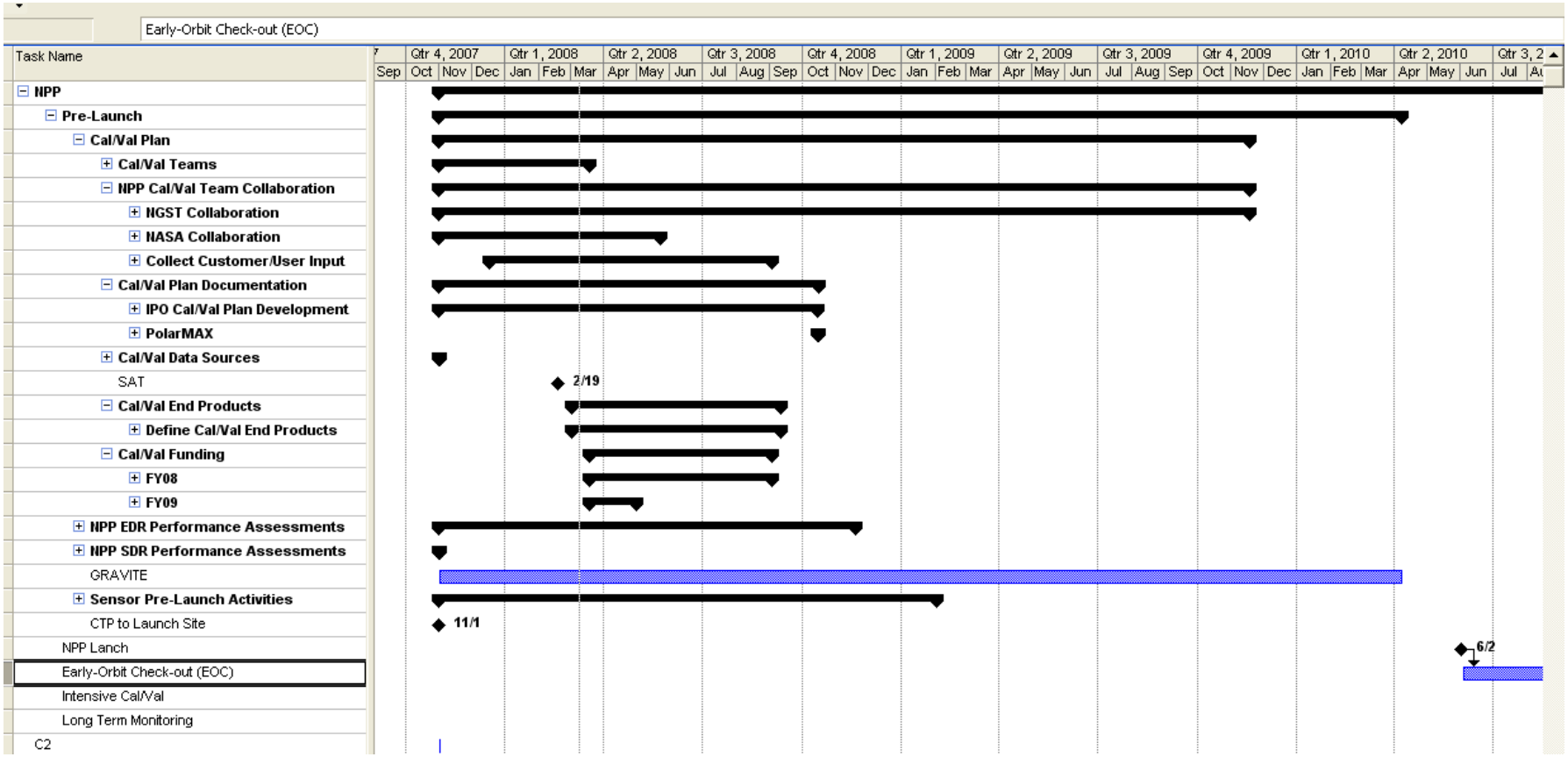


Expertise shifts from Contractor Sensor Engineers to Government Customers and Users over time and product chain.

IPO NPOESS Data Products Division Cal/Val Discipline Leadership

- **IPO cal/val funded activity for cal/val being led by user community experts**
  - **NASA, NOAA & DoD communities represented**
  - SDR
    - VIIRS – Bruce Guenther, IPO
    - CRIMMS - Gail Bingham, USU/SDL
    - OMPS Sounding Products – Scott Janz, GSFC
  - EDR
    - VIIRS Atmosphere: David Starr, GSFC
    - VIIRS Land: Jeff Privette, NCDC
    - VIIRS Ocean: Bob Arnone, NRL
    - VIIRS Imagery/Cloud Mask: Tom Kopp, Aerospace, AFWA
- **Cal/Val Leads recruit their own teams**
  - **Cal/Val Leads are developing plans**
- **Key near term events**
  - **Discipline Cal/Val Workshops mostly earlier this year**
  - **Cal/Val Peer Review (next week)**
- **Foster development of Customer/User endorsed Cal/Val Program.**

Cal/Val Overview
Plan Development Schedule



Major roles for NG in Calibration Core Team, Government oversight, Supplemented by other user and customer agencies

Highlights of VIIRS Senior Science Review Team Report

Meetings Dates: 27-28 Feb
Report Date: 18 March

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Overall Comments and Recommendations

- **VIIRS appears to an effective sensor**
  - Offers much to be excited about even as measured against the performance of MODIS, other heritage sensors.
  - SST and Imagery likely within specification on FU1

- **Priorities**
  - Deliver FU1 on schedule (as close as possible) is HIGH PRIORITY
  - Fix unresolved FU1 problems on FU2
  - Limit specification compliance concerns to Fields of View within 45 degrees of nadir; edge of scan performance should not drive schedule or cost
  - The improved IFA should be inserted into the first flight unit if the schedule opportunity arises - if risk assessment reasonable and experienced staff available

Senior Science Review (Menzel, Salomonson and Kopp)

Recommendations on FU1 Testing (1 of 2)

Topic [not priority ordered]	Current Program Status	
Polarization Knowledge Detector specific characterization knowledge is needed to enable image de-striping	***In baseline testing program*** New testing strategy under development, modeling will be assigned to IPO NRL optics expert for detailed prediction capability	
In-Lab Water Vapor Measurement 1.38 µm band characterization tests require reliable measurement of water vapor amount in lab for correction of test data	***Not in baseline testing program,*** ***In Consolidated Customer Consensus*** Improvements in measurement strategy (2nd humidity sensor) and implementation included on 19 March recommendations to the Program for added testing	
SWIR Bands Response Uniformity Large non-compliance (detector to detector stripes) needs to be resolved	***EFR 2384*** Is carried as "**red**" for PER Root cause not understood	

Recommendations on FU1 Testing (2 of 2)

Topic [not priority ordered]	Current Program Status	
Common/Different Temp Tests To separate cal target from sensor cavity effects	***Not in baseline testing program, Partly represented In Consolidated Customer Consensus*** Likely needed to close EFR 2386	⏳
More test data at 82K to support revised FPA set point	***Not in baseline testing program, In Consolidated Customer Consensus*** • Requires some characterization at 82K to sustain the change • Limited range of scene temperatures now included in test plan, need comprehensive set of scene temperatures in case cooler does not meet at-launch margins	⏳
Feasibility of End to End reflective solar calibration test should be studied	***Not in baseline testing program, Not in Consolidated Customer Consensus*** NIST proceeds with source development, expected delivery June 2008. Schedule considerations will be reviewed at that time.	⏳

VIIRS Sensor Performance in Comparison to MODIS

Murphy Charts
Still Under Study for F1 MODIS
VIIRS overlaps in approaches
Follow on upgrades

VisNIR Band Placement and BandWidth for VIIRS and MODIS against background of OC_C Water Leaving Radiance chart

VIIRS (M)oderate and (I)maging resolution bands numbered consecutively by increasing wavelength. VisNIR contains M1 .. M7, I1 and I2, Horizontal Cell Size ~ 750m

MODIS Vis and NIR focal planes combine to provide B1 & B2 (at 250m resolution NADIR), B3 & B4 (at 500m) and B7 to B16 (at 1000m); 1000m Atmospheric Water Vapor lines at 905, 936 and 940 nm not matched on VIIRS, not required for VIIRS products and are suppressed here

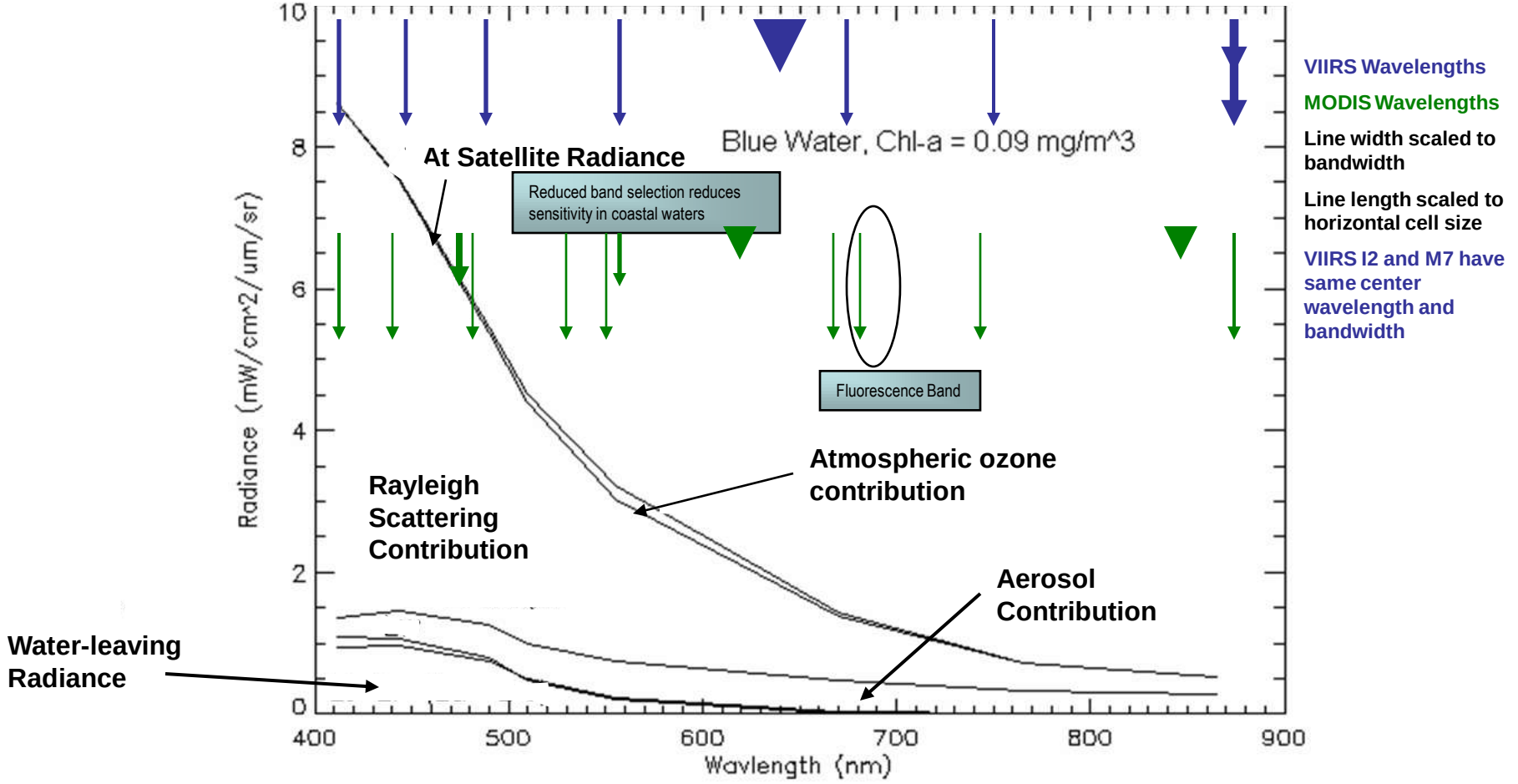


Figure from Evans, adapted by Pratt and adapted further for this work

Comparison of VIIRS SNR in Ocean Color Bands to MODIS and SeaWiFS

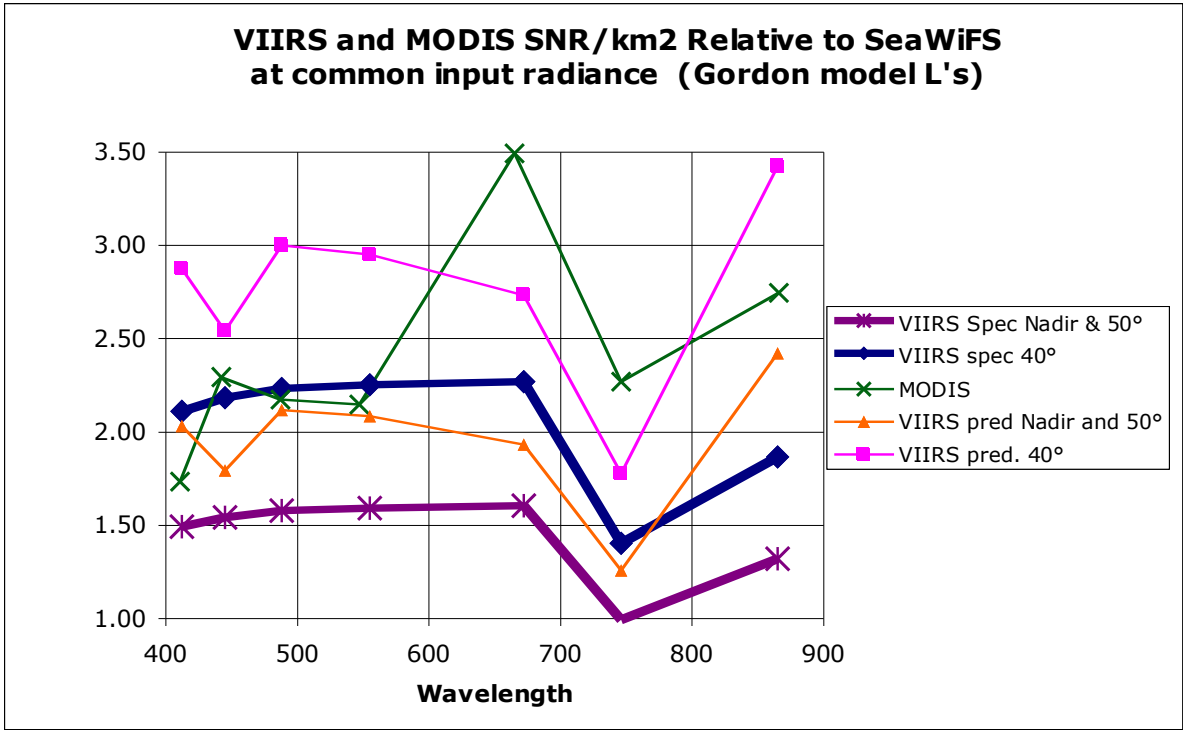


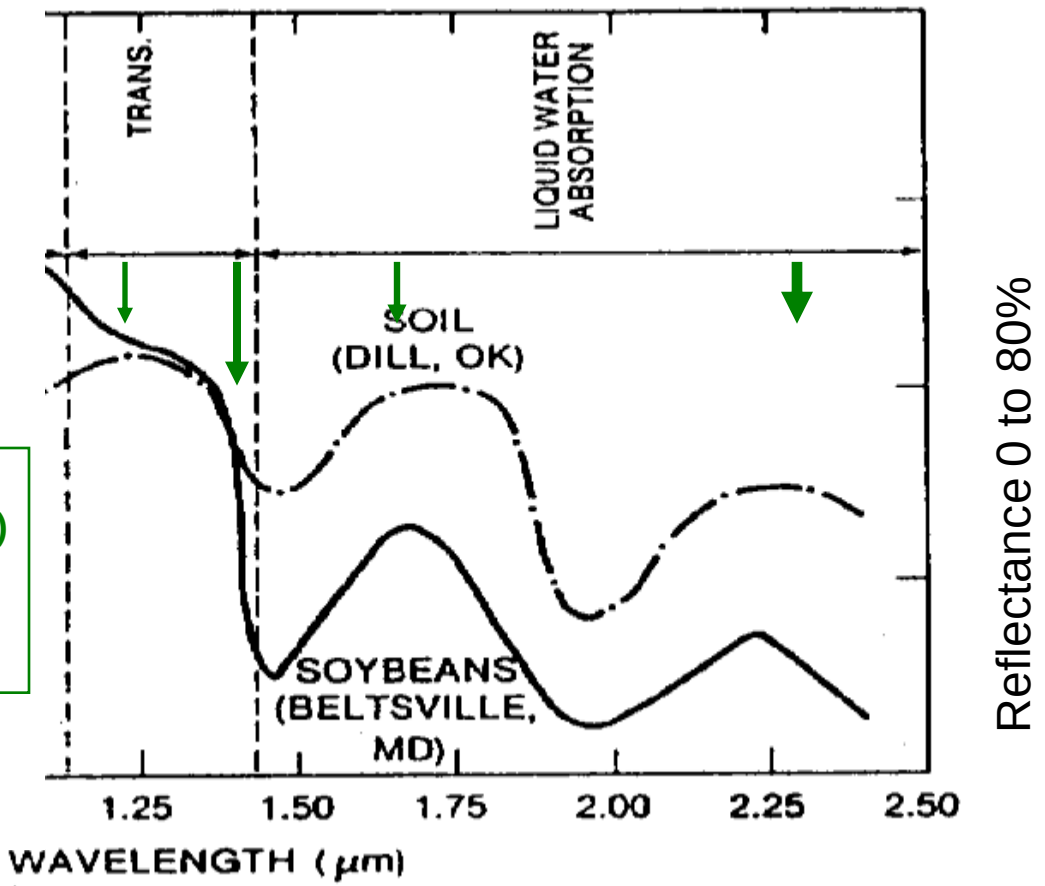
Figure 3 Comparison of VIIRS specified and predicted pixel level SNR adjusted for pixel area, and MODIS, relative to SeaWiFS performance. From *A Comparison of VIIRS Signal Noise Ratio Performance with SeaWiFS and MODIS*, by Wayne E. Esaias, October 3, 2004, an unpublished work

VIIRS measurement capability compares favorably to both MODIS and SeaWiFS when scaled to surface area of measurement, on the condition that VIIRS SNR improves with pixel aggregation as designed. The MODIS value near 667 nm is a fluorescence band on MODIS that is measured in Time-Delay Integration for an ocean fluorescence product that is not included in the NPOESS product suite and the measurement band is not incorporated into the VIIRS band set.

SWIR Bands on VIIRS and MODIS

VIIRS SWIR bands are I3 and M8, M9, M10 and M11 numbered in increasing wavelength, resolution ~ 750m

MODIS SWIR bands are B5, B6 and B7 (at 500m resolution NADIR) and B26 (at 1000m). Note that B6 on MODIS Aqua failed due to a focal plane defect



VIIRS Wavelengths — **Line width scaled to bandwidth**

MODIS Wavelengths — **Line length scaled to horizontal cell size**

Spectral reflectance signature of a photosynthetically active leaf with a soil signature to show contrast (Tucker and Seller, 1986), as shown in the MODIS Vegetation Index ATBD by Heute, et. Al. (1999) and adapted for this work

MODIS IR bands (in cm^{-1}) shown in context of a line-by-line radiative transfer computation for a U.S. Standard Atmosphere, with VIIRS equivalent bands also indicated.

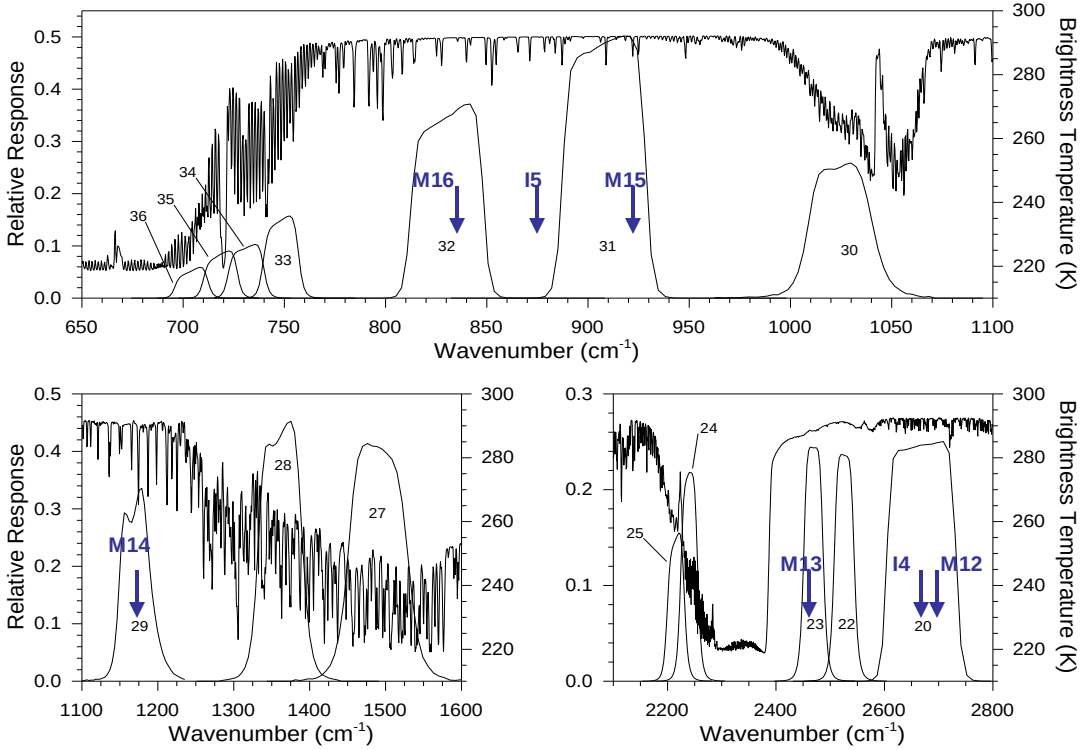


Figure 1: MODIS infrared spectral response. Nadir viewing emission spectrum of U.S. Standard Atmosphere from LBL-RTM., from MODIS Atmospheric Profile Retrieval ATBD, from S. Seemann, et. al., 2006.

MODIS To VIIRS Band Selection

VIIRS Radiometric						VIIRS Geometric			MODIS Radiometric						
Band Name	Band Ctr	Band Width	L_{typ}	SNR/ NEDT		GSD Nadir (m)	GSD 850 km (m)	GSD EOS (m)	MODIS Band #	l Min	Band Width	L_{typ}	L_{max}	NEDL /NEDT	SNR
M1	412 nm	20 nm	155(44.9)	316(352)		742	1093	1597	8	405 nm	15 nm	(44.9)	175	0.051	(880)
M2	445 nm	18 nm	146(40)	409(380)		742	1093	1597	9	438 nm	10 nm	42	133	0.050	176(838)
M3	488 nm	20 nm	123(32)	414(416)		742	1093	1597	10	483 nm	10 nm	.3 (32)	593	.145/.04	43 (802)
M4	555 nm	20 nm	90(21)	315(362)		742	1093	1597	12	546 nm	10 nm	29	518	.127/.028	28 (750)
I1	640 nm	80 nm	22	119		371	547	799	1	620 nm	50 nm	22			(129)
M5	672 nm	20 nm	68(10)	360(242)		742	1093	1597	13	662 nm	10 nm	9.5	32	0.011	913
M6	746 nm	15 nm	9.6	199		742	1093	1597	15	743 nm	10 nm	10	26	0.017	(600)
M7	865 nm	39 nm	33.4(6.4)	340(215)		742	1093	1597	16	862 nm	15 nm				
I2	865 nm	39 nm	25	150		371	547	799	2	841 nm	36 nm	25	285	0.123	01 (314)
M8	1.24 m	0.020 m	5.4	101		742	1093	1597	5	1.23 m	0.02 m	5.4	110	0.073	74
M9	1.378 m	0.015 m	6	83		742	1093	1597	26	1.36 m	0.030 m	6	90	0.040	150
M10	1.61 m	.06 m	7.3	342		742	1093	1597	6	1.63 m	0.02 m	7.3	70	0.027	270
I3	1.61 m	.06 m	7.3	6		371	547	799							
M11	2.25 m	.05 m	.12	167		742	1093	1597	7	2.11 m	0.05 m	1	22	0.009	111
M12	3.70 m	.18 m	270	0.396		742	1093	1597	20	3.66 m	0.18 m	300K	335	0.050	470
I4	3.74 m	.38 m	270	2.5		371	547	799							
M13	4.05 m	.16 m	380(300)	423(.107)		742	1093	1597	23	4.02 m	0.06 m	300K	328	0.050	364
M14	8.55 m	0.3 m	270	.091		742	1093	1597	29	8.40 m	0.30 m	300K	324	0.050	1065
M15	10.8 m	1.0 m	300K	.070		742	1093	1597	31	10.78 m	0.50 m	300K	324	0.050	1362
M16	12.0 m	1.0 m	300K	.072		742	1093	1597	32	11.77 m	0.50 m	300K	324	0.050	1475
I5	11.5 m	1.9 m	210K	1.5		371	547	799							
DNB	700 nm	400 nm	6.67E-5	6		742	1093	1597							

MODIS Bands not included in VIIRS		Red=Imaging Band
B11, B14	Ocean color and fluorescence	Blue = High Gain Band
B17, B18, B19	Precipitble water	Black= All other Bands
B22	SST	VIIRS Data are from Spec (Jan, 2002)
B24, B25, B27, B28	Sounding	MODIS Data are Spec
B30	Ozone	Units: W/(m2-sr-µm)
B33, B34, B35, B36	Sounding	

VIIRS RSB Noise wrt Spec

Band	CW (nm)	SNR Specified	SNR Median Value	% Margin @ Median	Minimum % Margin	# Non-Compliant Detectors	Gain [dn/(W/m^2/sr/μm)]
M1 LG	412	316	1182.3	274.15%	261.39%	0	6.6863
M1 HG	412	352	717.8	103.92%	91.42%	0	28.2248
M2 LG	445	409	1053.3	157.53%	148.61%	0	5.0463
M2 HG	445	380	567.8	49.42%	44.24%	0	24.6321
M3 LG	488	414	1106.1	167.17%	160.70%	0	4.5051
M3 HG	488	416	666.7	60.26%	56.06%	0	27.4743
M4 LG	555	315	943.4	199.49%	181.49%	0	4.7677
M4 HG	555	362	537.6	48.51%	43.31%	0	36.0415
M5 LG	672	360	789.3	119.25%	103.92%	0	5.1919
M5 HG	672	242	335.2	38.51%	33.39%	0	52.0804
M6	746	199	349.2	75.48%	67.64%	0	81.5965
M7 LG	865	340	786.8	131.41%	115.44%	0	9.4987
M7 HG	865	215	533.6	148.19%	132.19%	0	103.2540
M8	1240	74	327.7	342.84%	226.89%	0	27.5229
M9	1378	83	222.1	167.59%	127.71%	0	36.9066
M10	1610	342	799.6	133.80%	51.14%	0	48.8022
M11	2250	NA	NA	NA	NA	NA	105.7940
I1	640	119	346.5	191.18%	130.25%	0	4.8065
I2	865	150	275.8	83.87%	73.47%	0	9.8656
I3	1610	6	166.5	2675.00%	2533.33%	0	44.4908

https://collab2.st.northropgrumman.com/eRoom/PayloadSensors/VIIRS/0_9dc3b for HSR of I-bands, MTF, BBR and FOV

VIIRS TEB Noise wrt Spec

Band	CW (nm)	NEdT (K) Specified	NEdT (K) Median Value	% Margin @ Median	Minimum % Margin	# Non-Compliant Detectors	NEdL ($W/m^2/sr/um$)	Dark Noise (DN)	Band	Gain [$dn/(W/m^2/sr/\mu m)$]
M12	3700	0.396	0.110946	256.93%	117.59%	0	0.000565	0.165714	**M12**	1203.31
M13	4050	0.107	0.059749	79.08%	71.49%	0	0.001883	0.142788	**M13 LG** **M13 HG**	6.84736 612.159
M14	8550	0.091	0.045262	101.05%	45.69%	0	0.005636	0.579428	**M14**	183.961
M15	10763	0.07	0.024388	187.03%	133.22%	0	0.003697	0.218181	**M15**	170.935
M16A	12013	0.072	0.029441	144.56%	23.40%	0	0.003371	0.221491	**M16A**	196.467
M16B	12013	0.072	0.028877	149.33%	109.46%	0	0.003501	0.232271	**M16B**	197.276
I4	3740	2.5	0.311318	703.04%	572.05%	0	0.001735	0.536499	**I4**	1161.13
I5	11450	1.5	0.311184	382.03%	220.78%	0	0.012407	0.590326	**I5**	123.313

https://collab2.st.northropgrumman.com/eRoom/PayloadSensors/VIIRS/0_9dc3b for HSR of I-bands, MTF, BBR and FOV

Still Under Study for F1

- Number of testing updates over EDU for F1
  - Most significant is additional of second nominal vacuum test plateau
- Polarization testing not yet complete
- Demonstration of radiometric performance mainly in TEB (EFR2386)
- Reduction of stripes in SWIR bands (EFR2384)
- Impact of Dewar ghosting in SWMWIR bands (EFR3326)
- Demonstration of sensor stability through spacecraft TV testing
- Greater control of test analysis process by customer team

MODIS–VIIRS Overlaps in Approaches

- NGST will build Core Calibration team
  - IPO will provide added Government Team Core Team Members
    - Weekly coordination calls (as in MODIS MsWG) to keep Disciplines and Calibration Teams in coordination with representatives for each discipline
      - continuity with Atmospheres, Ocean, but not yet Land)
- IPO Projects funding to UWisc, Wolfe, Optics – Walucshka, Xiong/NICST, Minnett, Standards lab measurements of reflectance witness samples, SIS cal via Biggar – including comparisons to APS test source to be performed in next 5 days
- *Last Shall be First* and *First Shall be Last* (in detector space)

Test Fixture Upgrade Potentials F2 Unit

- NIST developing End-to-End test equipment for SD in-place effective BRDF
- Augmented linearity (bootstrap technique) may be needed
- Improved spectral out of band for VisNIR (expect to demonstrate at NPP spacecraft level) with Traveling Sircus
- Develop scene generator calibrator target

These items are currently funded or planned for FY09 development at NIST with IPO Project

VIIRS Anticipated Caveats

EDU Items

F1 Items

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Known F1 Items

- VisNIR optical cross-talk
  - IFA problem impacts Ocean Color and likely AOT
- Gain switch: noise and linearity
- 3.70 µm (M12), edge detector (#1 in detector-space-TBR on “Bad Detector” list for gain and noise-but still useable)
- Ghosting at detectible level in cooled focal planes – shown effect to be below noise for LWIR in aggregated pixel zones with proxy data, effect in SWMWIR (TBD)
- High spectral out of band component for 0.412 µm (M1) (need to integrate effect in SIS calibrations to make radiometry work)
  - Encourage you here, **and in all cases**, to use full in band and out of band spectral response functions to make analysis work in radiometrically sensitive applications)

Another F1 Item, Comments Pls

- 1.246 μm (M8) saturates at 130 W/(m^2-sr-μm), and spec set at L_{max} of 164. I think this is OK, and expect to recommend modifying spec, do you care?

Under-performing to Spec, Better MODIS

- Polarization characteristics F1 within spec, but pre-launch characterization knowledge (TBD)
- Scatter characteristics in structured scenes
- SD cavity scatter not measured

Additional Considerations, Comments

- Fire Product Status
  - At best F1 will under-perform MODIS-Aqua
  - Will work with UMCP for continuing development
- No solution on horizon for water vapor winds capability
- Sensor design changes (new Non-Recurring Engineering) for F2 to be locked down by ~ July 2008
  - BG involved in that process, send me your recommendations (by Discipline Group)