Generation of OLI data products Onboard Earth Observing One: A Preliminary Report

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Goals

- General: Demonstrate that hyperspectral data can be used to synthesize multispectral data onboard.
- Specific: Demonstrate that Hyperion Hyperspectral data can be used to synthesize OLI multispectral data onboard.

Approach

- Utilize existing capabilities
  - Autonomous Sciencecraft (ASE) Flight Software [Chien et al. 2005] in use to operate EO-1 2004 – present.
  - ASE includes
    - Onboard Hyperion Data Analysis
    - Onboard mission re-planning
    - Onboard execution

ASE Usage

- ASE onboard instrument processing used to demonstrate onboard:
  - Surface water extent mapping (Flood detection)
  - Cryosphere tracking (Snow, Water, Ice, Cloud, Land)
  - Thermal Analysis (Volcano, Wildfire)
- Over 5000 onboard products generated 2004-present [Chien et al. 2013 JSTARS]

ASE Instrument Data Processing

- Band stripping capability
  - Implemented by Microtel
  - Enables band stripping of 12 Hyperion Bands
    - Must include at least 1 SWIR and 1 VNIR band
    - Strips out 1024 x 256 pixel image
    - Requires ~ 20 minutes to strip
  - ASE provides
    - Standard interface for accessing the stripped data
    - Standard interface to output data product
    - Data is then downlinked via s-band

Implementation Steps

- Identify selected Hyperion Bands
- Compile out as much computation as possible
- Validate convolution algorithms on ground
  - Convolve ALI data to assist in validation
- Implement to ASE interface spec
- Validate in ground testbeds
- Upload and flight validate
- Operations within current ASE operations framework – no significant disruption to EO-1 operations

Operations Constraints

- Only 12 bands (1 SWIR 1 VNIR)
  - Will need to demonstrate OLI band convolution with not all OLI bands form a single band strip
- WARP contention constraint
  - WARP playback (band stripping) and WARP writing (image acquisition) cannot overlap

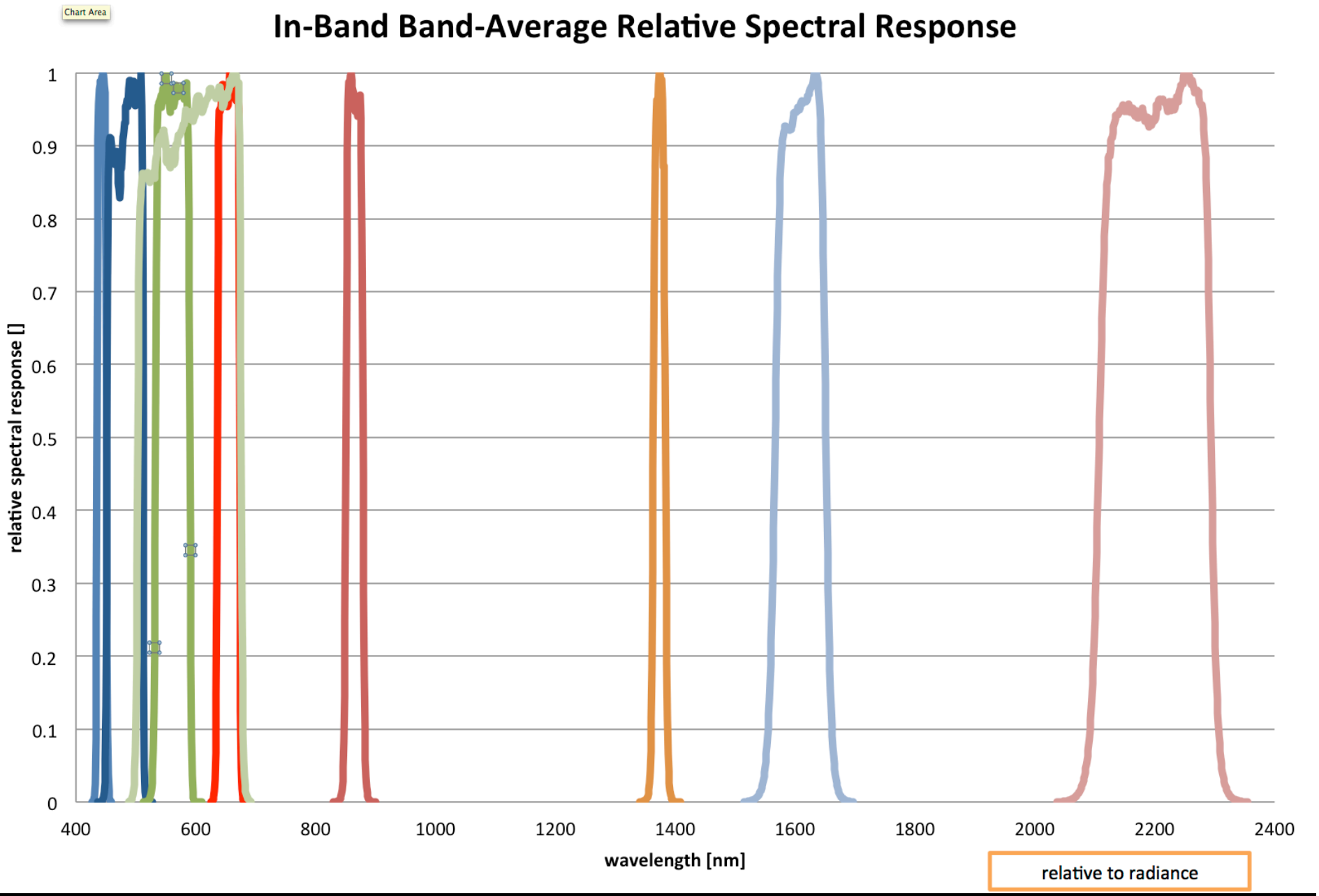
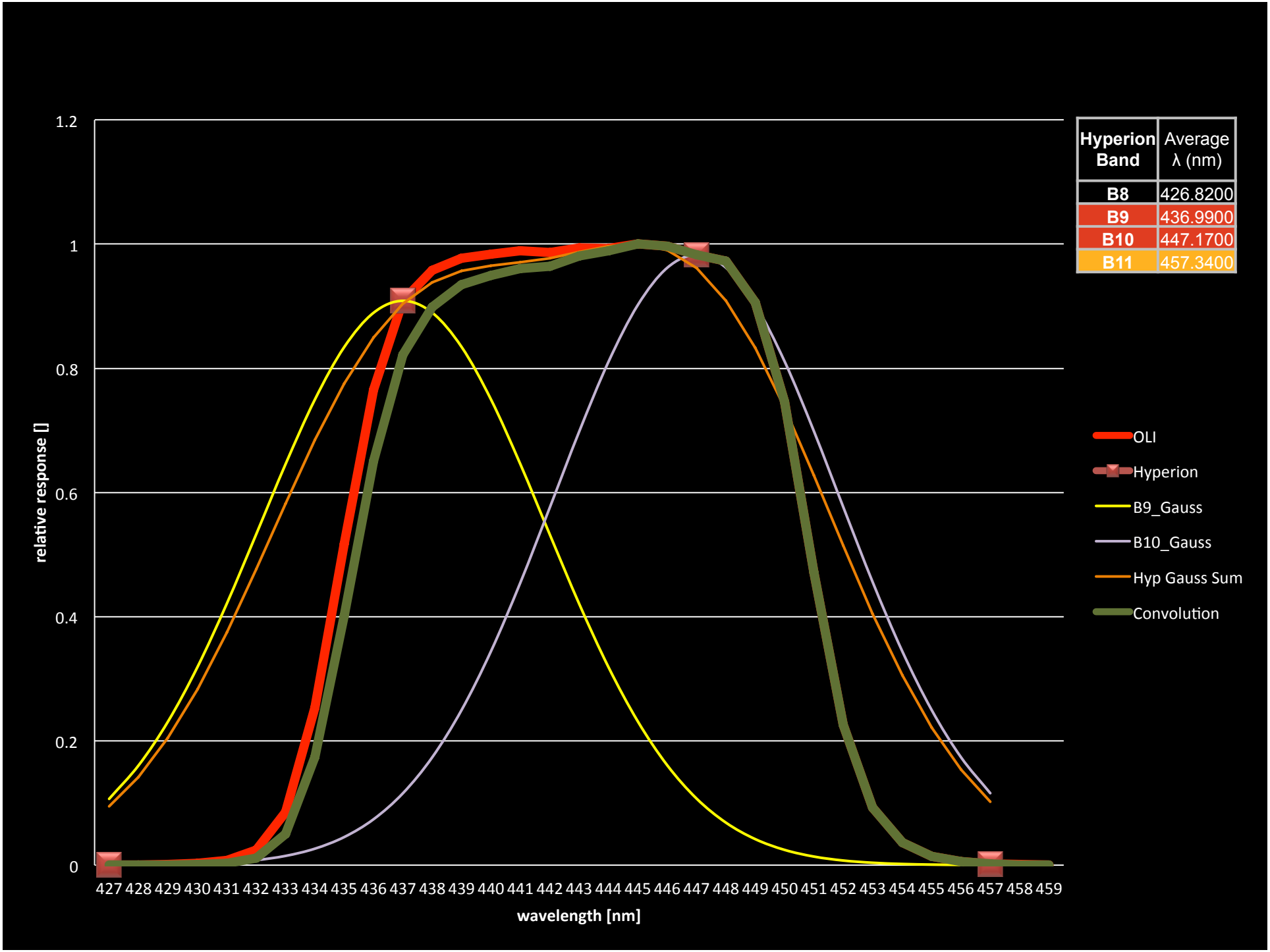
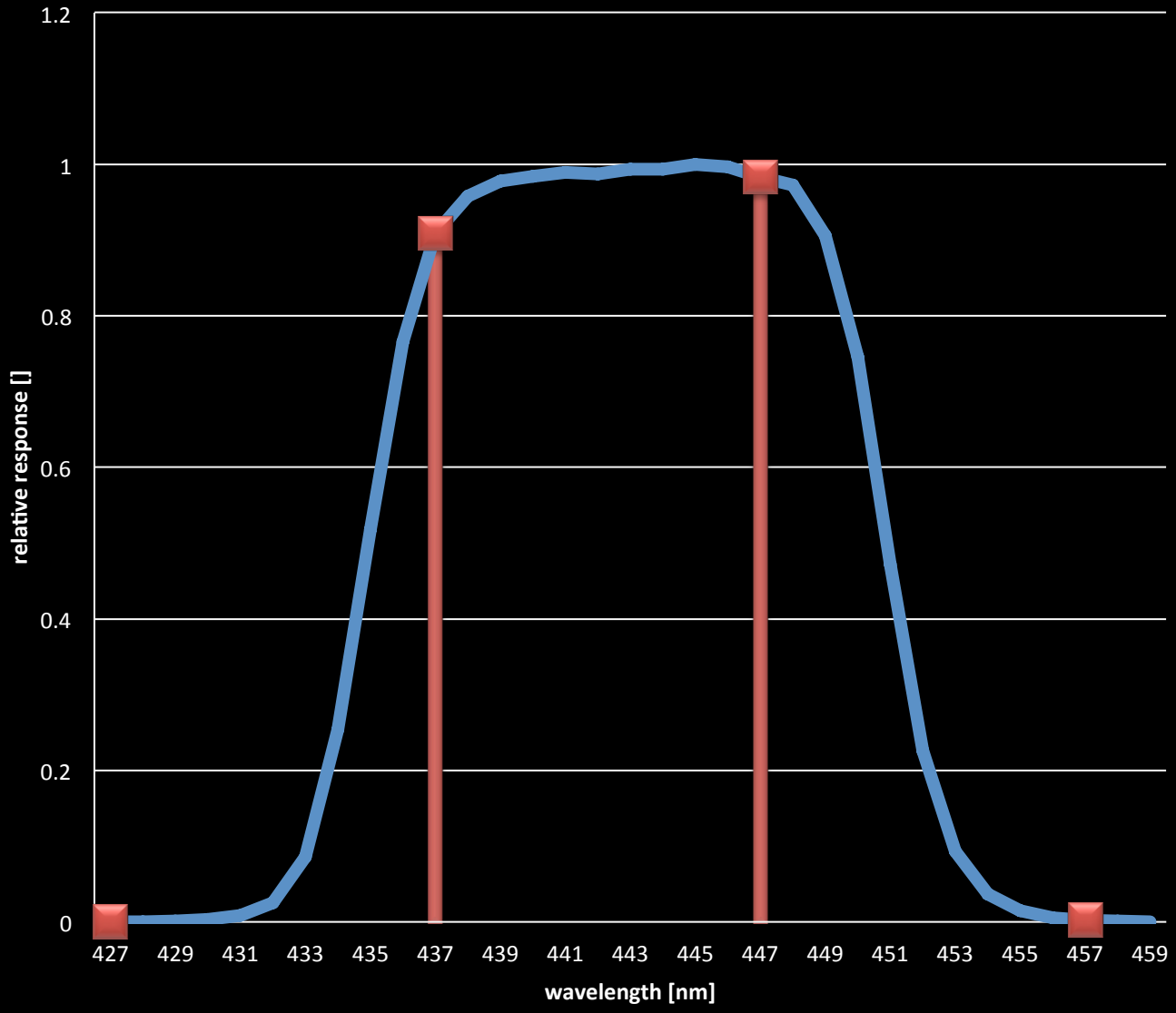


Chart Area
In-Band Band-Average Relative Spectral Response
relative spectral response []
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
wavelength [nm]
relative to radiance


Hyperion Band
Average λ (nm)
B8
426.8200
B9
436.9900
B10
447.1700
B11
457.3400
OLI
Hyperion
B9_Gauss
B10_Gauss
Hyp Gauss Sum
Convolution
relative response []
wavelength [nm]
1.2
1
0.8
0.6
0.4
0.2
0
427 428 429 430 431 432 433 434 435 436 437 438 439 440 441 442 443 444 445 446 447 448 449 450 451 452 453 454 455 456 457 458 459

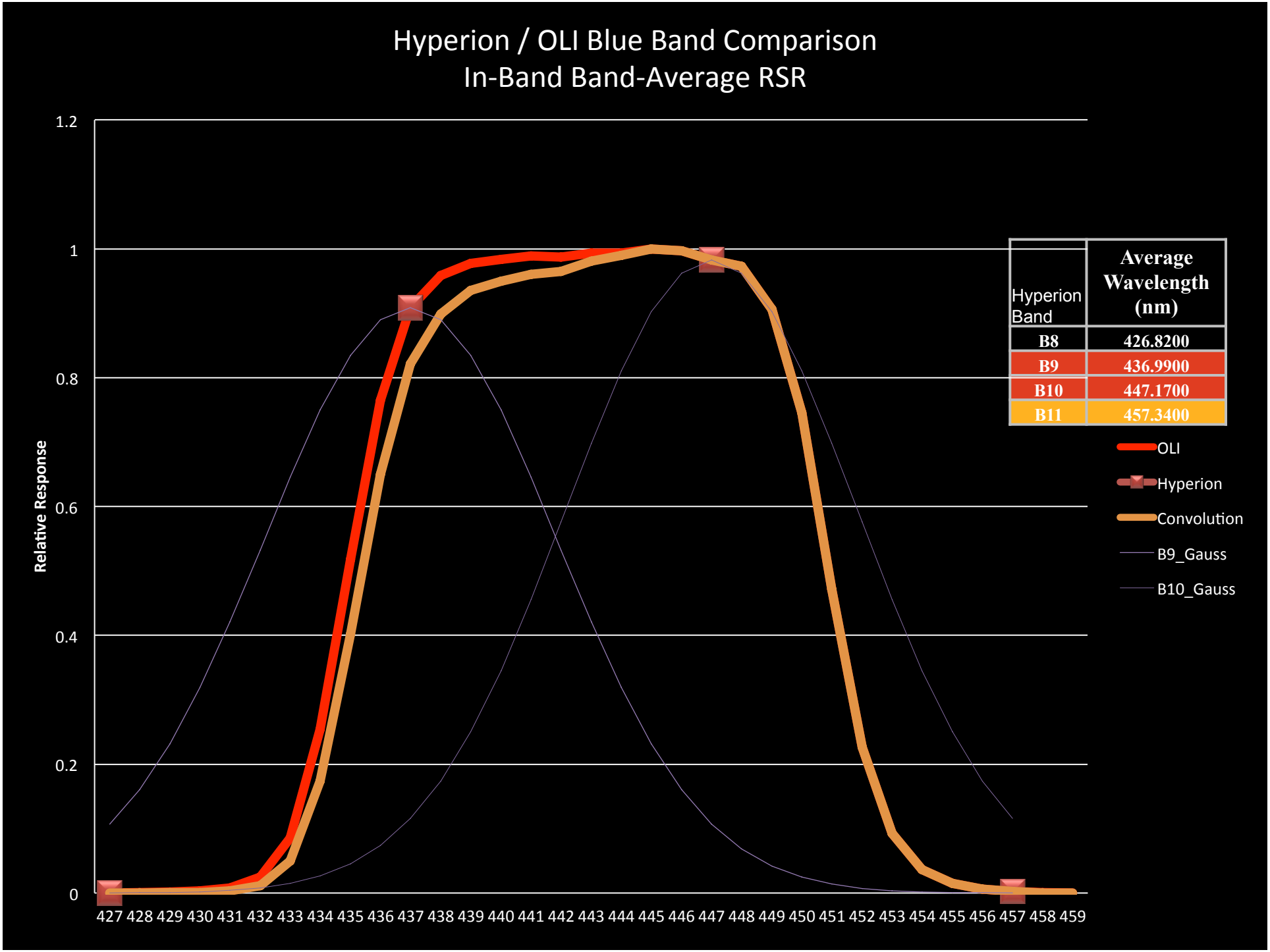
Hyperion / OLI Coastal/Aerosol Band Comparison
In-Band Band-Average RSR



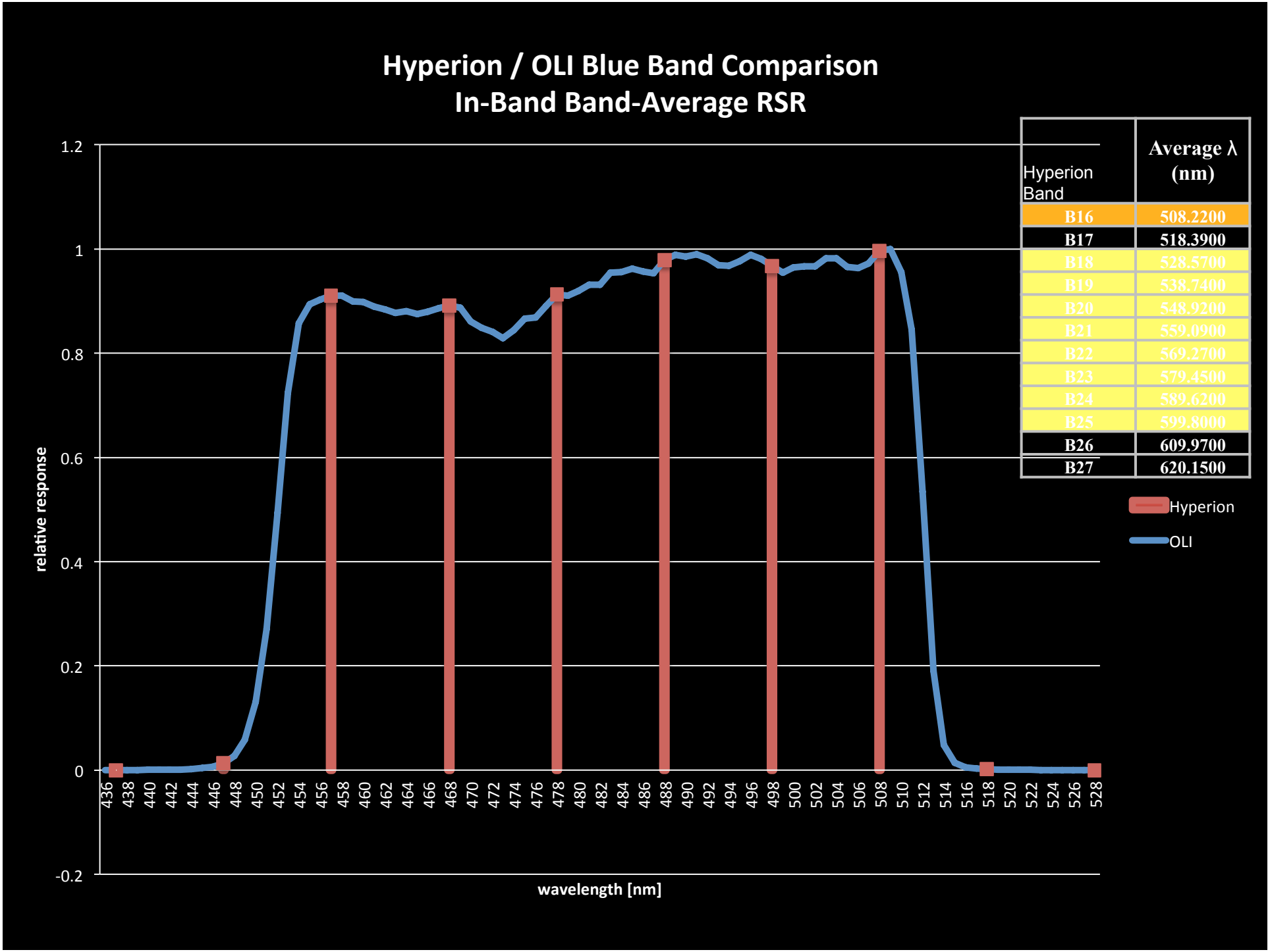
Hyperion Band	Average λ (nm)
B8	426.8200
B9	436.9900
B10	447.1700
B11	457.3400

OLI

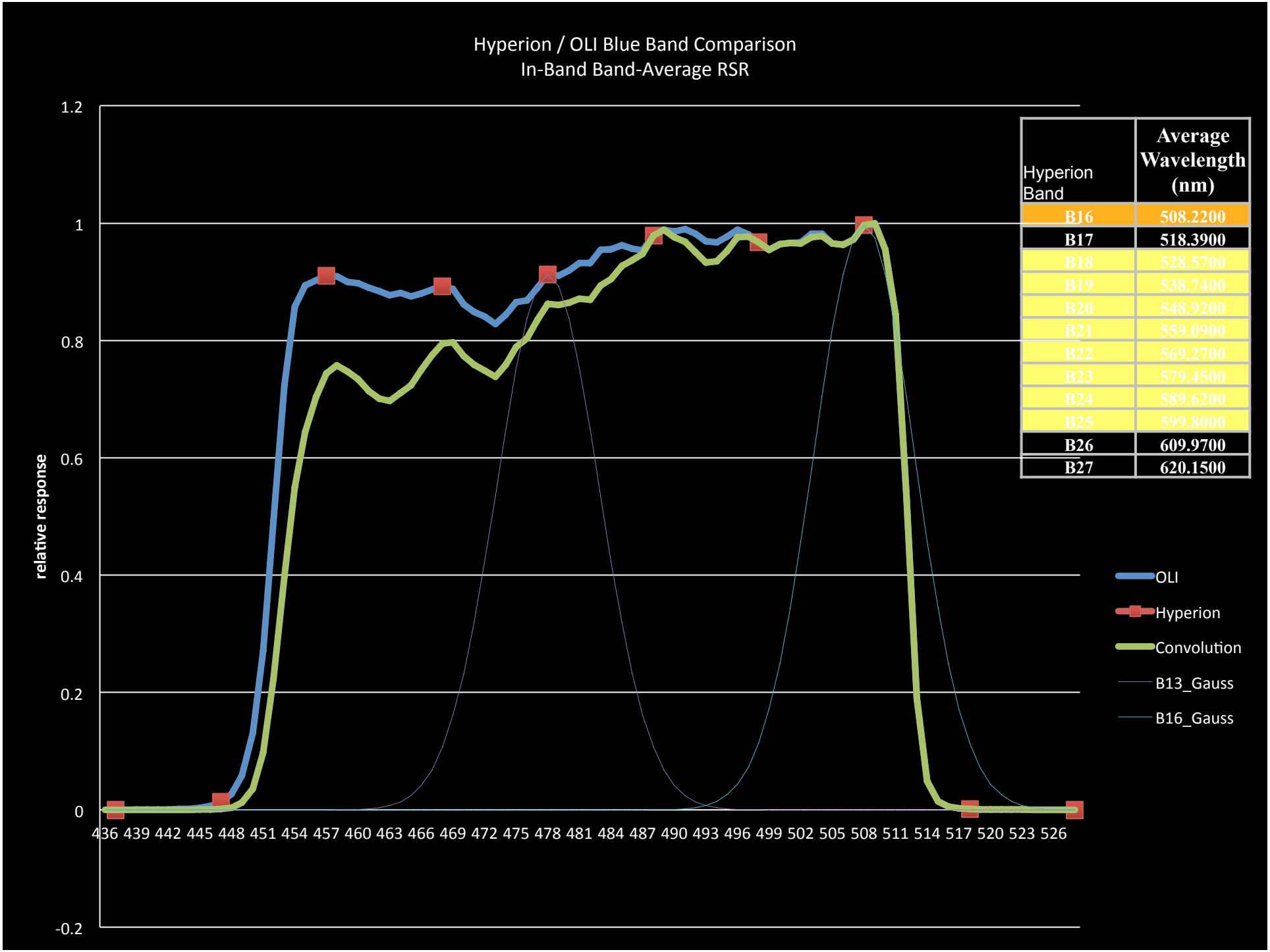
Hyperion


Hyperion / OLI Blue Band Comparison
In-Band Band-Average RSR
Relative Response
1.2
1
0.8
0.6
0.4
0.2
0
427 428 429 430 431 432 433 434 435 436 437 438 439 440 441 442 443 444 445 446 447 448 449 450 451 452 453 454 455 456 457 458 459
Hyperion Band
Average Wavelength (nm)
B8
426.8200
B9
436.9900
B10
447.1700
B11
457.3400
OLI
Hyperion
Convolution
B9_Gauss
B10_Gauss

Hyperion / OLI Blue Band Comparison
In-Band Band-Average RSR

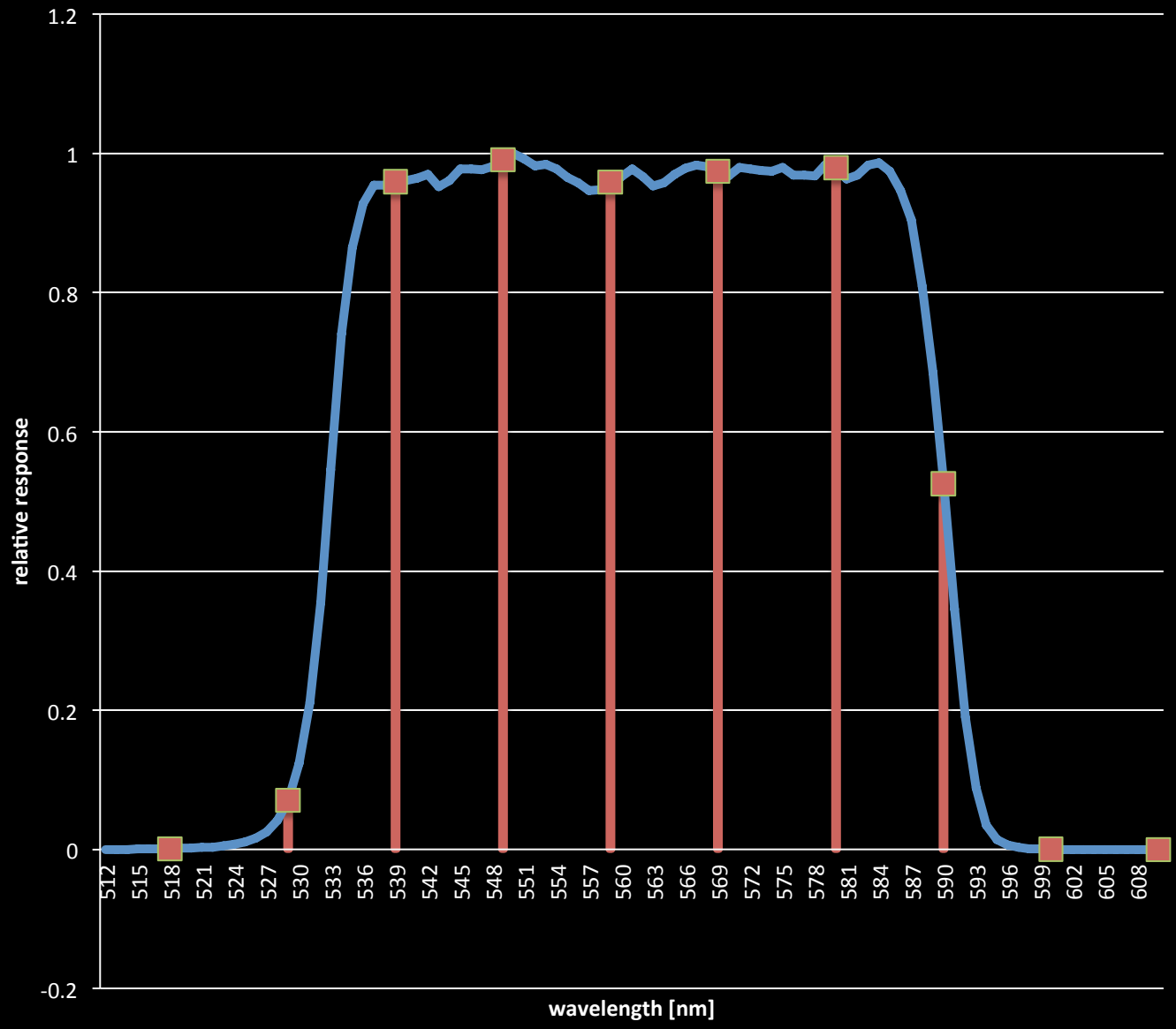


Hyperion Band	Average λ (nm)
B16	508.2200
B17	518.3900
B18	528.5700
B19	538.7400
B20	548.9200
B21	559.0900
B22	569.2700
B23	579.4500
B24	589.6200
B25	599.8000
B26	609.9700
B27	620.1500



Hyperion Band	Average Wavelength (nm)
B16	508.2200
B17	518.3900
B18	528.5700
B19	538.7400
B20	548.9200
B21	559.0900
B22	569.2700
B23	579.4500
B24	589.6200
B25	599.8000
B26	609.9700
B27	620.1500

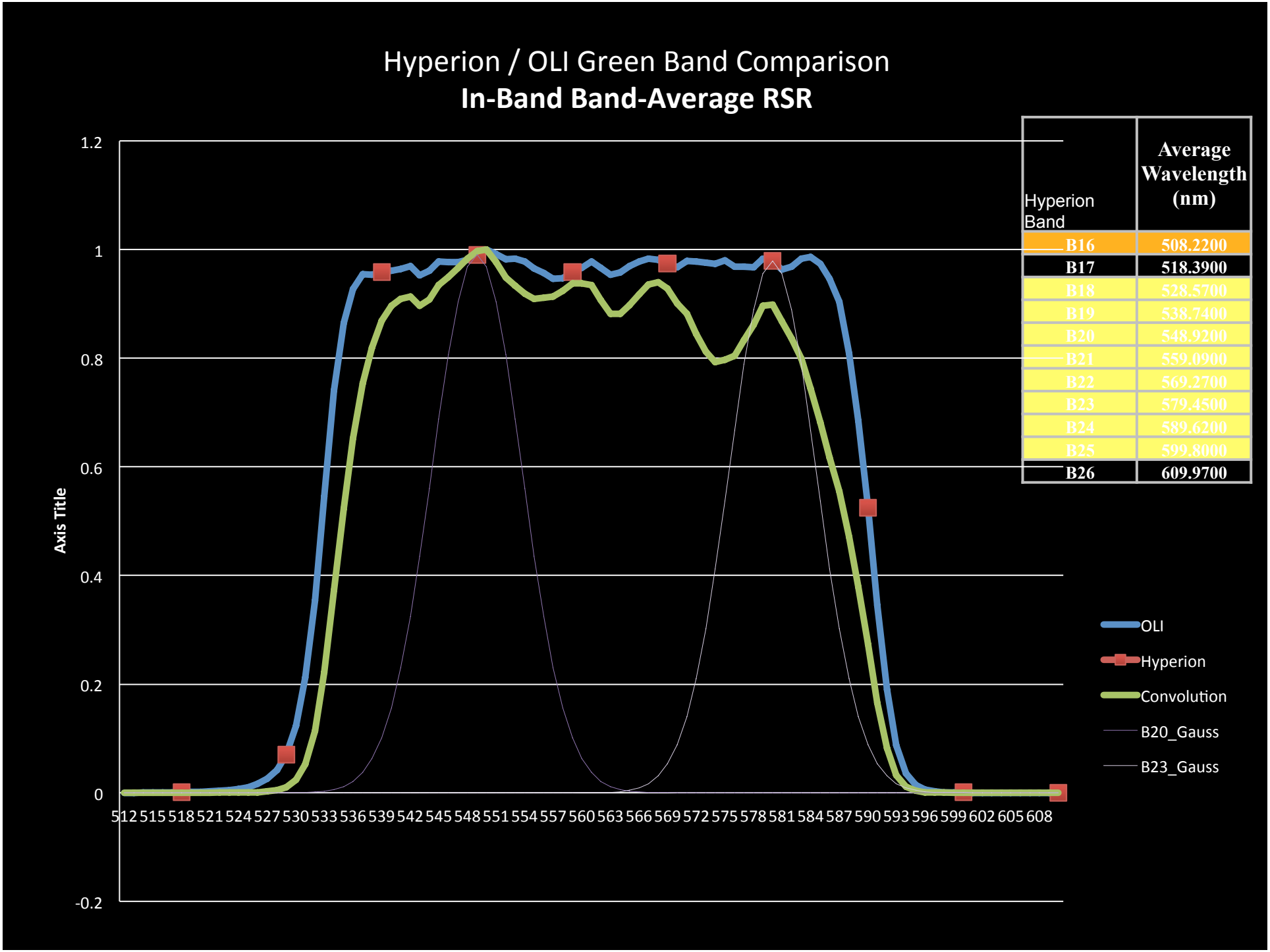
Hyperion / OLI Green Band Comparison
In-Band Band-Average RSR



Hyperion Band	Average Wavelength (nm)
B16	508.2200
B17	518.3900
B18	528.5700
B19	538.7400
B20	548.9200
B21	559.0900
B22	569.2700
B23	579.4500
B24	589.6200
B25	599.8000
B26	609.9700

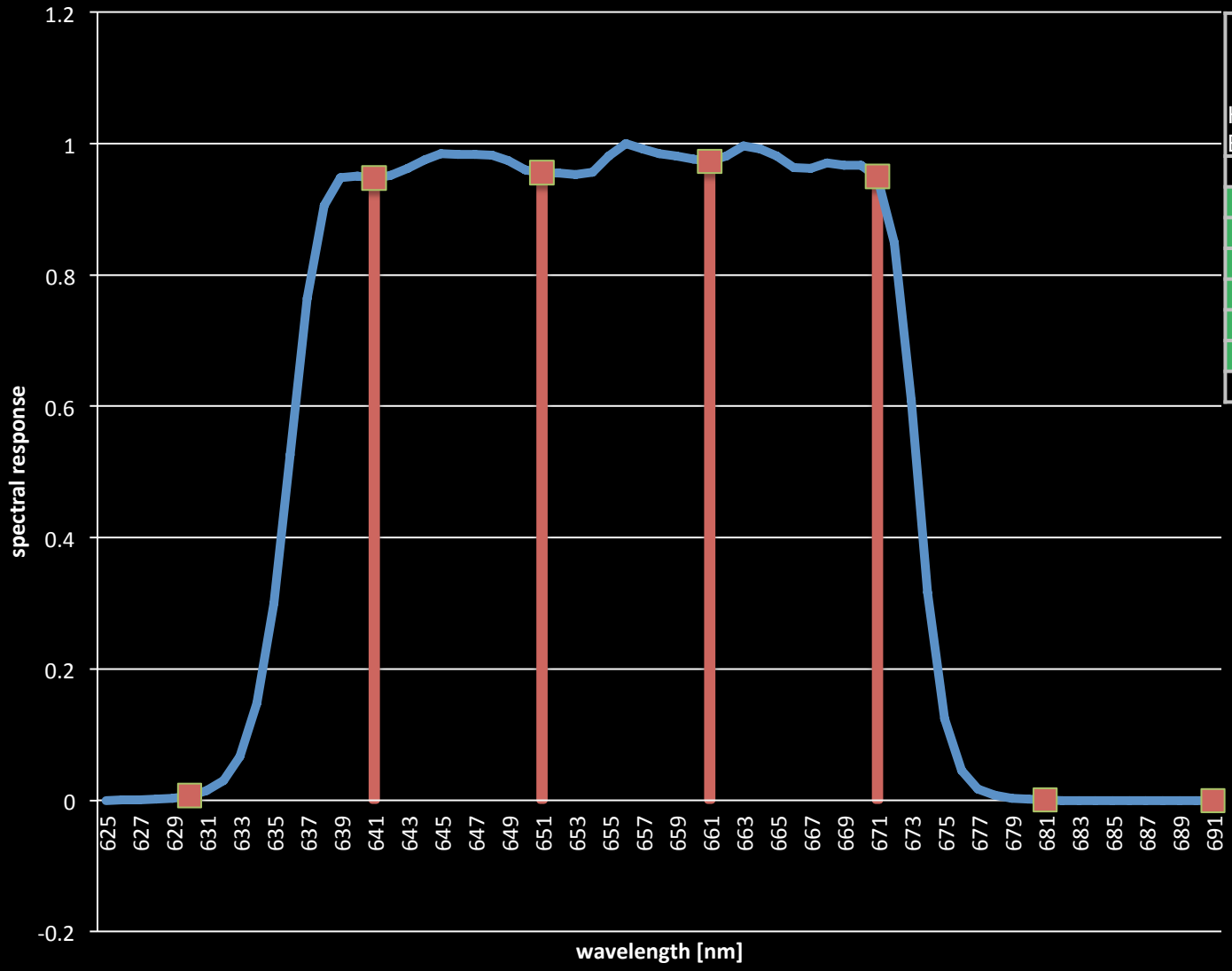
Hyperion

OLI



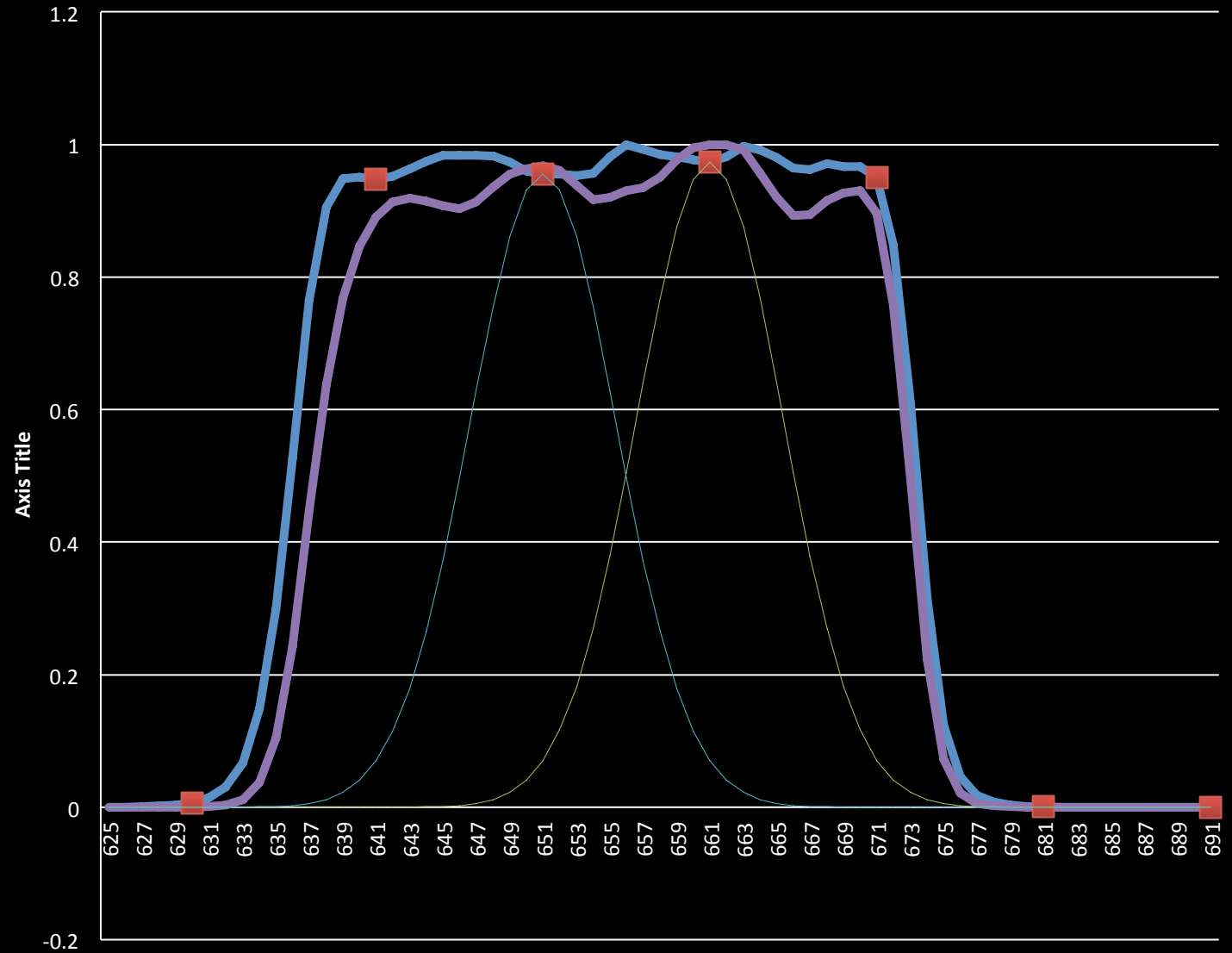
Hyperion Band	Average Wavelength (nm)
B16	508.2200
B17	518.3900
B18	528.5700
B19	538.7400
B20	548.9200
B21	559.0900
B22	569.2700
B23	579.4500
B24	589.6200
B25	599.8000
B26	609.9700

Hyperion / OLI Red Band Comparison
In-Band Band-Average RSR



Hyperion Band	Average λ (nm)
B27	620.1500
B28	630.3200
B29	640.5000
B30	650.6700
B31	660.8500
B32	671.0200
B33	681.2000
B34	691.3700

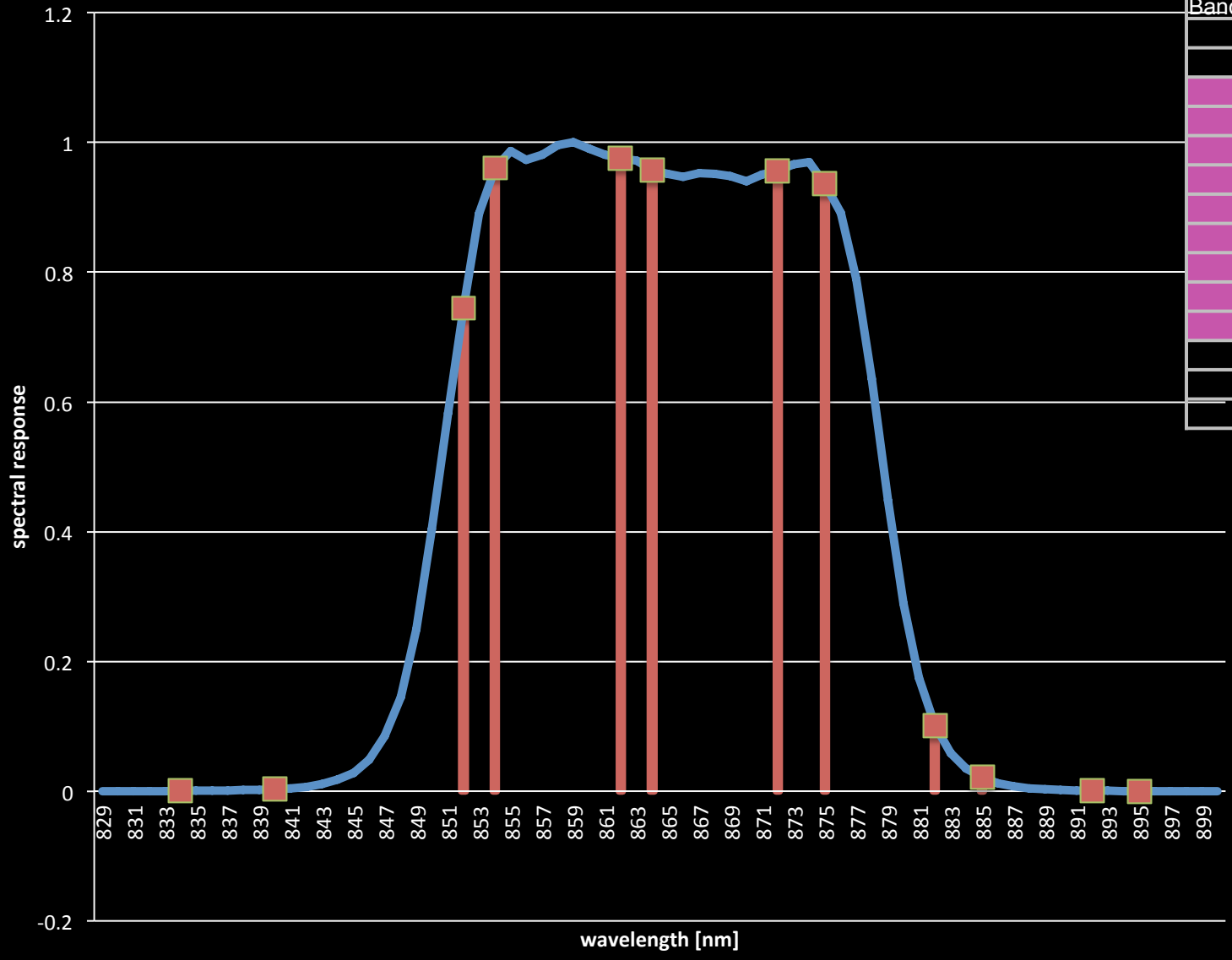
Hyperion / OLI Red Band Comparison
In-Band Band-Average RSR



Hyperion Band	Average λ (nm)
B27	620.1500
B28	630.3200
B29	640.5000
B30	650.6700
B31	660.8500
B32	671.0200
B33	681.2000
B34	691.3700

OLI
Convolution
Hyperion
B31_Gauss
B30_Gauss

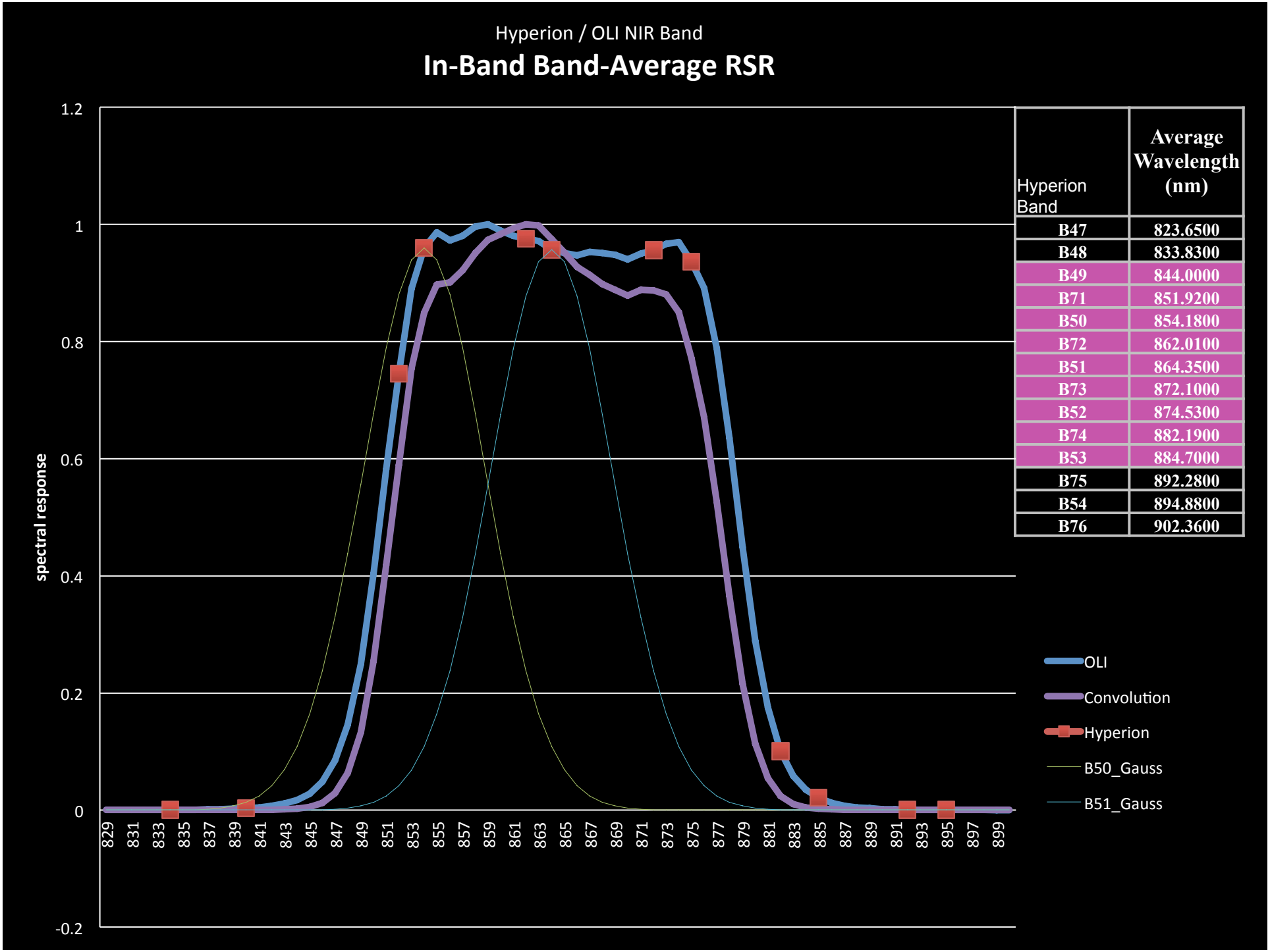
Hyperion / OLI NIR Band
In-Band Band-Average RSR



Hyperion Band	Average Wavelength (nm)
B47	823.6500
B48	833.8300
B49	844.0000
B71	851.9200
B50	854.1800
B72	862.0100
B51	864.3500
B73	872.1000
B52	874.5300
B74	882.1900
B53	884.7000
B75	892.2800
B54	894.8800
B76	902.3600

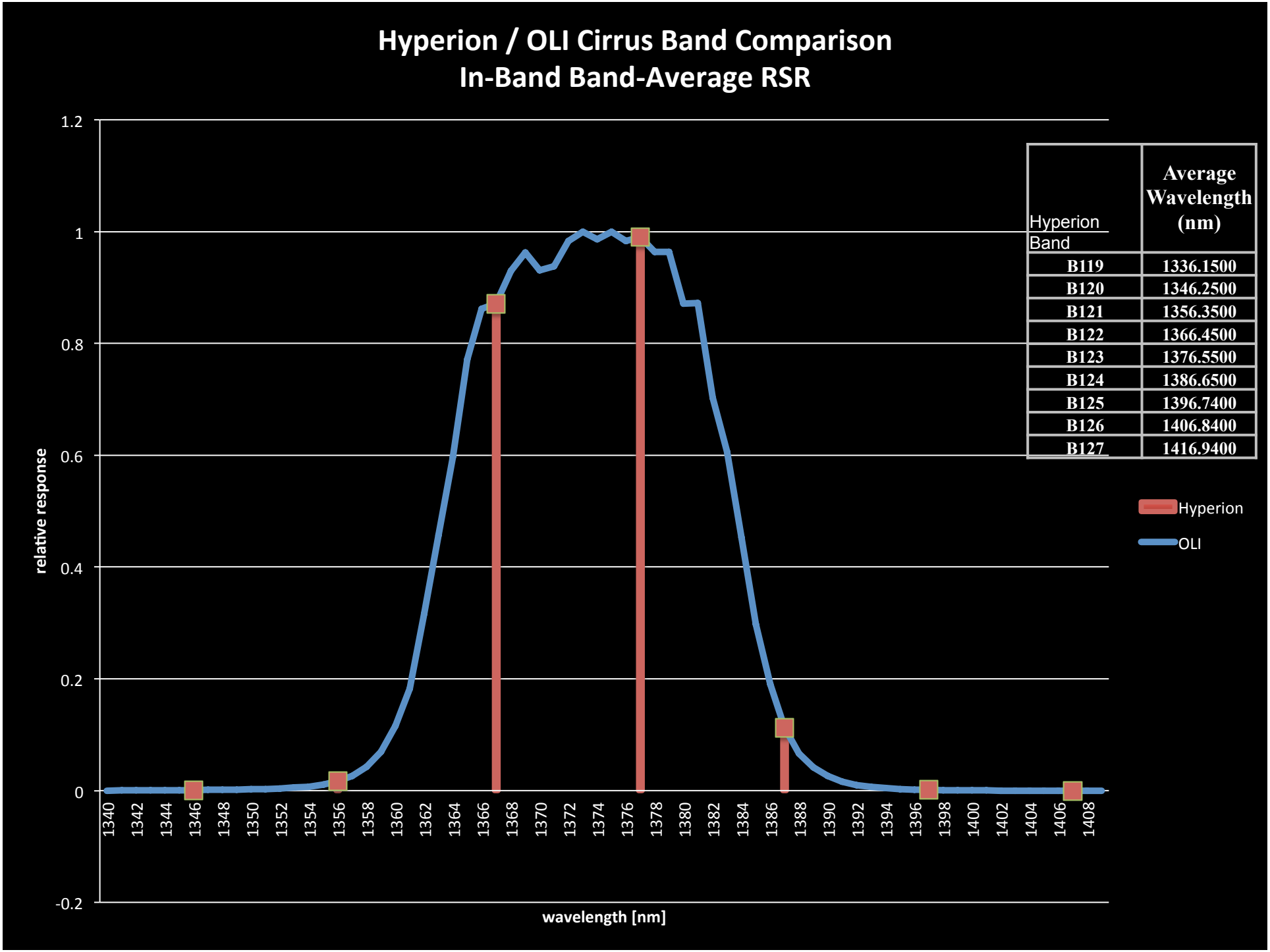
Hyperion / OLI NIR Band

In-Band Band-Average RSR

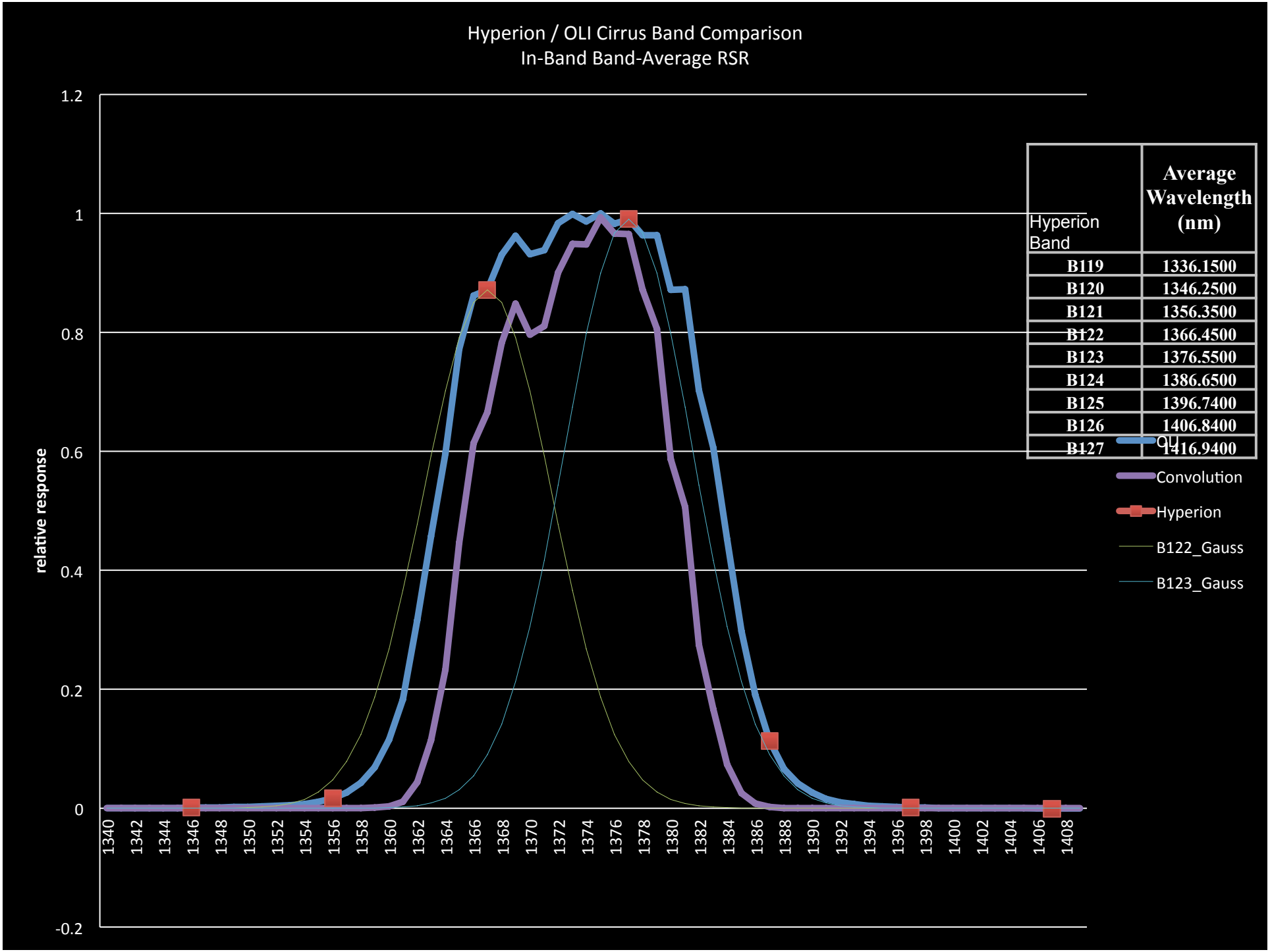


Hyperion Band	Average Wavelength (nm)
B47	823.6500
B48	833.8300
B49	844.0000
B71	851.9200
B50	854.1800
B72	862.0100
B51	864.3500
B73	872.1000
B52	874.5300
B74	882.1900
B53	884.7000
B75	892.2800
B54	894.8800
B76	902.3600

Hyperion / OLI Cirrus Band Comparison
In-Band Band-Average RSR

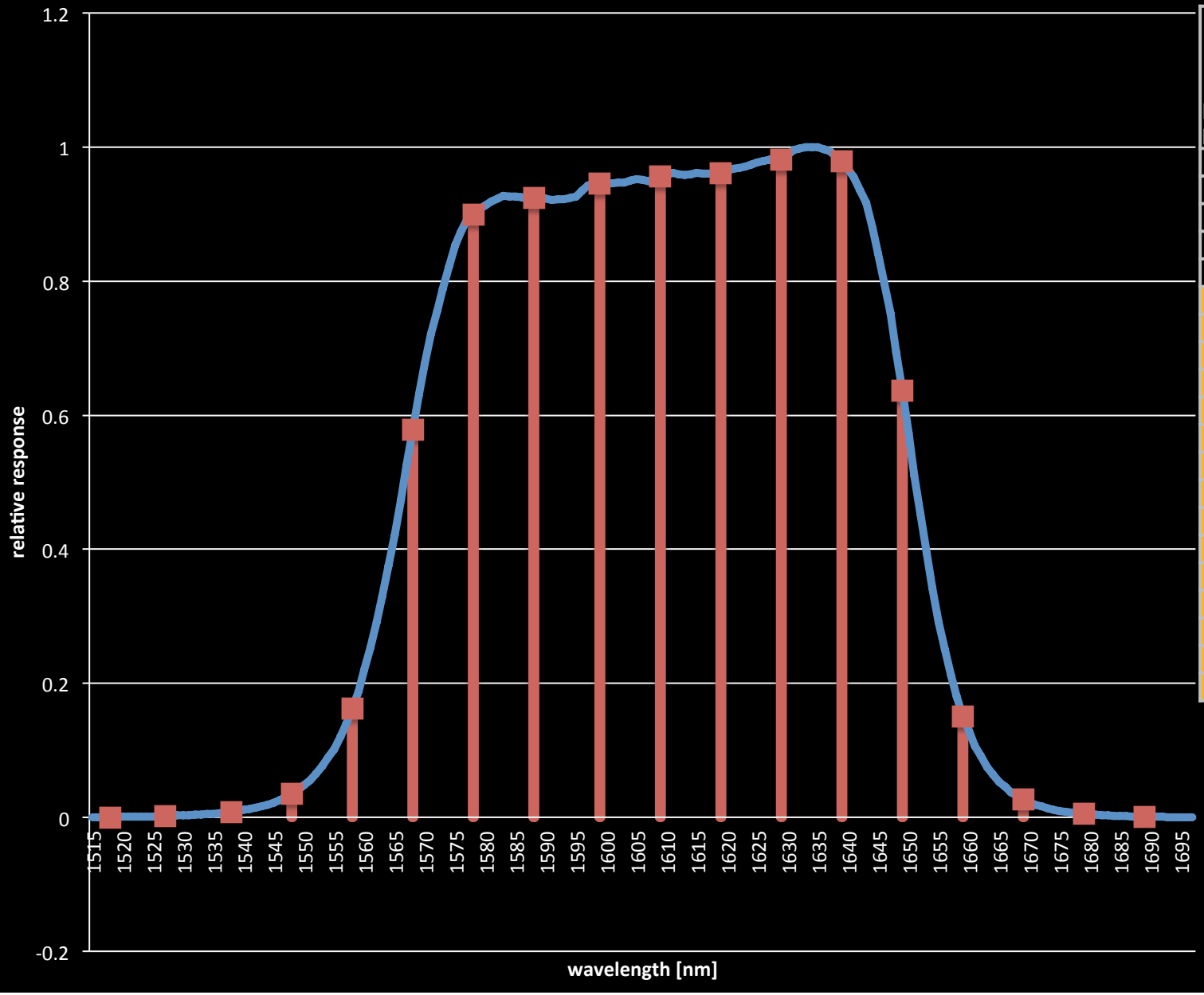


Hyperion Band	Average Wavelength (nm)
B119	1336.1500
B120	1346.2500
B121	1356.3500
B122	1366.4500
B123	1376.5500
B124	1386.6500
B125	1396.7400
B126	1406.8400
B127	1416.9400



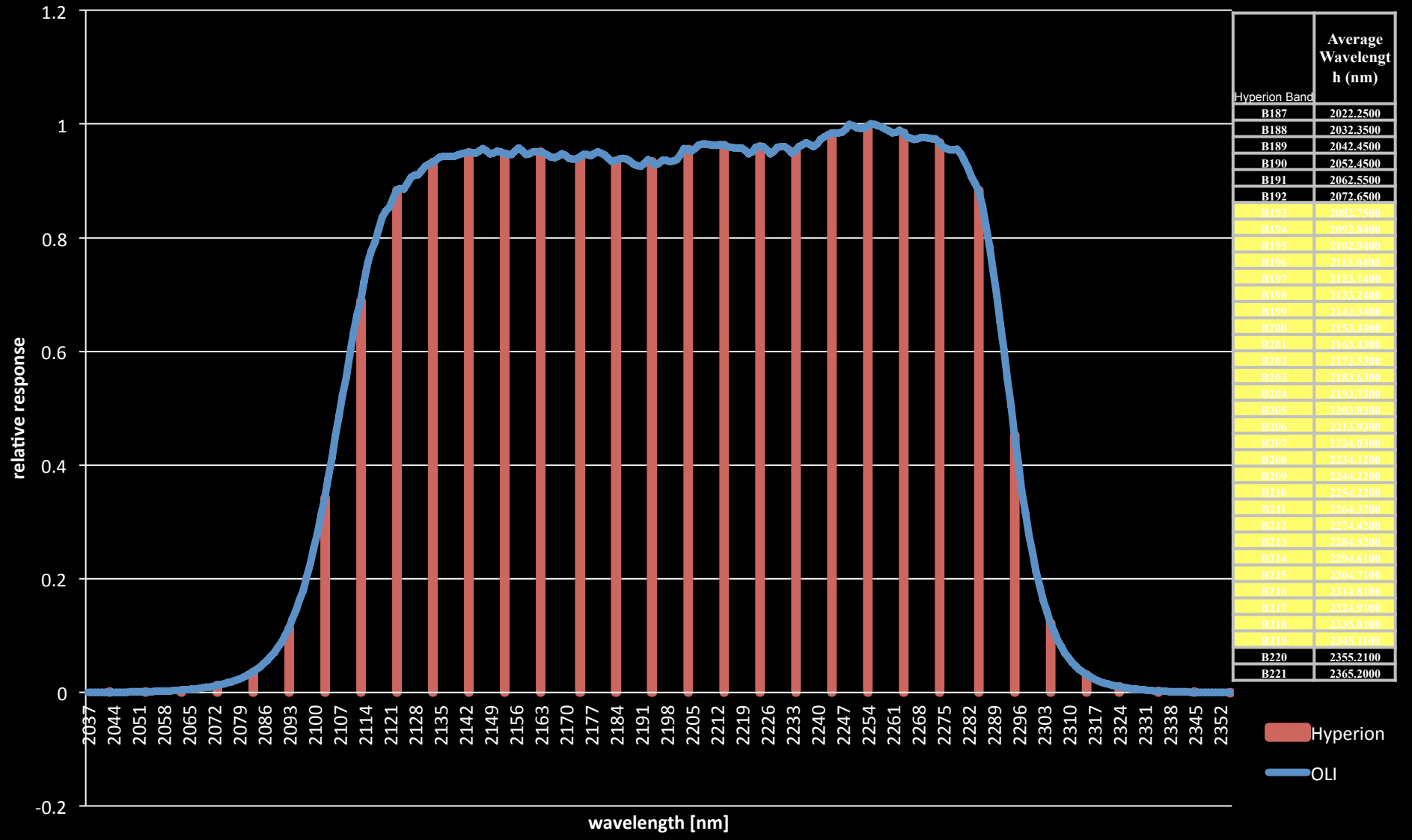
Hyperion Band	Average Wavelength (nm)
B119	1336.1500
B120	1346.2500
B121	1356.3500
B122	1366.4500
B123	1376.5500
B124	1386.6500
B125	1396.7400
B126	1406.8400
B127	1416.9400

Hyperion / OLI SWIR1 Band Comparison
In-Band Band-Average RSR



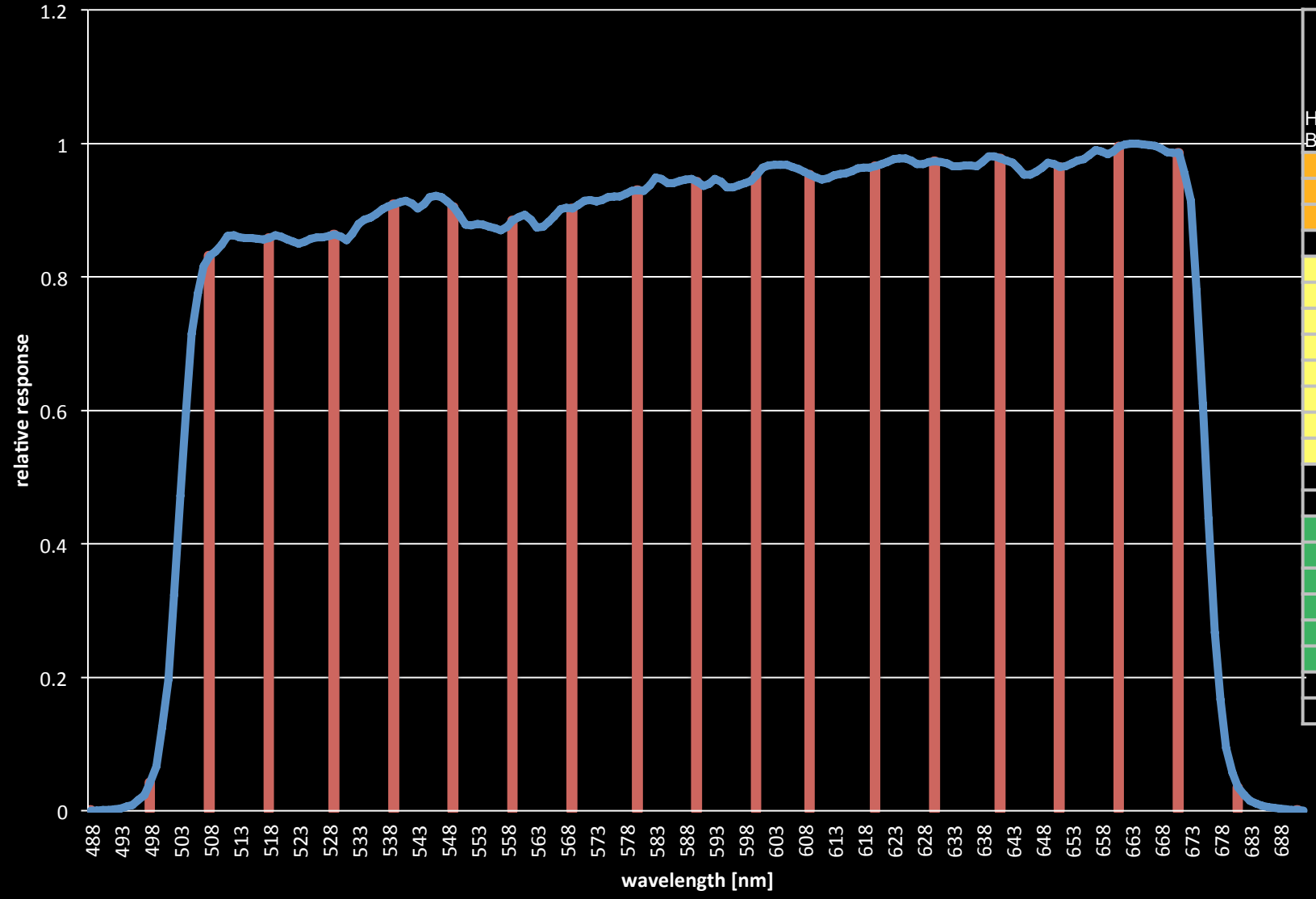
Hyperion Band	Average Wavelength (nm)
B136	1507.7300
B137	1517.8300
B138	1527.9200
B139	1537.9200
B140	1548.0200
B141	1558.1200
B142	1568.2200
B143	1578.3200
B144	1588.4200
B145	1598.5100
B146	1608.6100
B147	1618.7100
B148	1628.8100
B149	1638.8100
B150	1648.9000
B151	1659.0000
B152	1669.1000
B153	1679.2000
B154	1689.3000
B155	1699.4000

Hyperion / OLI SWIR2 Band Comparison
In-Band Band-Average RSR



Hyperion Band	Average Wavelength (nm)
B187	2022.2500
B188	2032.3500
B189	2042.4500
B190	2052.4500
B191	2062.5500
B192	2072.6500
B193	2082.7500
B194	2092.8400
B195	2102.9400
B196	2113.0400
B197	2123.1400
B198	2133.2400
B199	2143.3400
B200	2153.3400
B201	2163.4300
B202	2173.5300
B203	2183.6300
B204	2193.7300
B205	2203.8300
B206	2213.9300
B207	2224.0300
B208	2234.1200
B209	2244.2200
B210	2254.2200
B211	2264.3200
B212	2274.4200
B213	2284.5200
B214	2294.6100
B215	2304.7100
B216	2314.8100
B217	2324.9100
B218	2335.0100
B219	2345.1100
B220	2355.2100
B221	2365.2000

Hyperion / OLI PAN Band Comparison
In-Band Band-Average RSR



Hyperion Band	Average Wavelength (nm)
B14	487.8700
B15	498.0400
B16	508.2200
B17	518.3900
B18	528.5700
B19	538.7400
B20	548.9200
B21	559.0900
B22	569.2700
B23	579.4500
B24	589.6200
B25	599.8000
B26	609.9700
B27	620.1500
B28	630.3200
B29	640.5000
B30	650.6700
B31	660.8500
B32	671.0200
B33	681.2000
B34	691.3700
B35	701.5500

Conclusions

- EO-1 mission has excellent supporting infrastructure to flight validate OLI product generation onboard
  - Hyperion has sufficient spectral resolution to synthesize OLI data
  - ASE FSW on EO-1 supports band stripping access to Hyperion data (with 12 band limitation)
  - Preliminary work to implement convolution, identify candidate relevant bands, overall design is complete
  - Flight validation can be executed with modest effort
- Future enhancement to band stripping could enable even further capability
  - Generation of more OLI bands within single pass
  - Downlink via WARP and X-band