

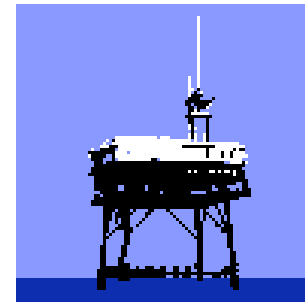
Preliminary Comparison of Theory and Observation for Ocean-reflected Surface Radiance at COVE

Wenying Su

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Ken Rutledge, and Thomas P. Charlock

(NASA Langley Research Center)



CERES Science Team Meeting, Jan 23-25, Williamsburg, VA

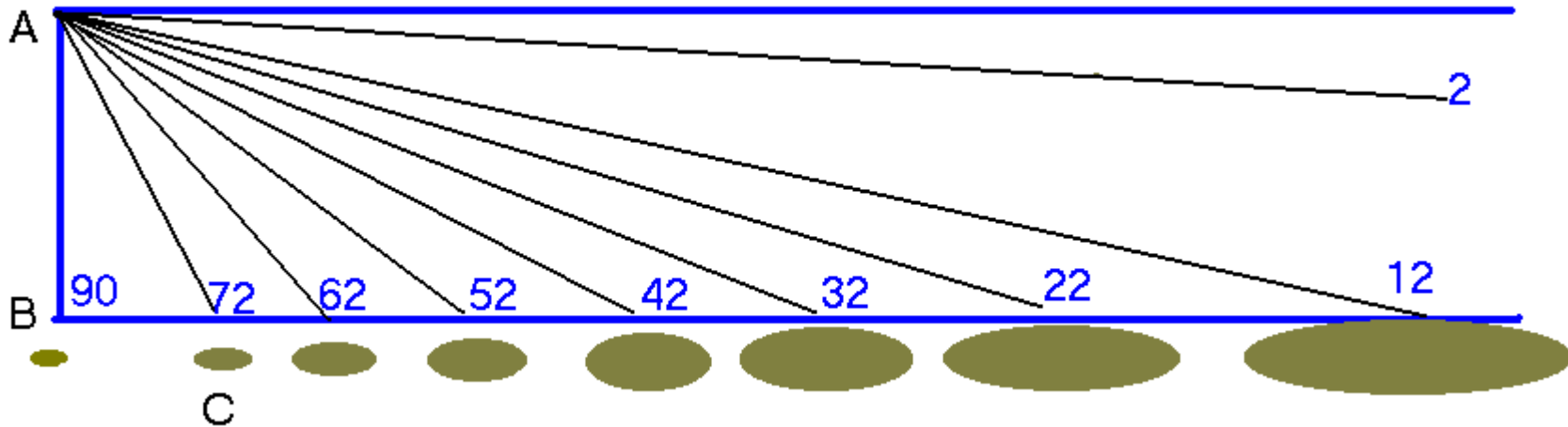
Spectrophotometer SP1A

The multi-channel Spectrophotometer SP1A is for spectral measurements in a range between 350 nm and 1050 nm. The spectrophotometers are accurately calibrated using laboratory equipment.

Channel	CWL (± 2 nm)	FWHM (nm)
01	353	3
02	368	3 ¹
03	389	3
04	412	4 ¹
05	450	4
06	500	5 ¹
07	532	5
08	600	6 ¹
09	675	5 ¹
10	760	6
11	778	6 ¹
12	862	6 ¹
13	911	8
14	946	8
15	967	8
16	1024	8 ¹
17	1045	10
18	1064	10



Measurement Scheme



AB: height of SP1A, 23.165 meters.

Elevation angle	AC	BC	Diameter (m)
2	663.76	663.35	265.58
12	111.42	108.98	8.98
22	61.84	57.33	2.82
32	43.71	37.07	1.42
42	34.62	25.73	0.89
52	29.40	18.10	0.65
62	26.24	12.32	0.52
72	24.36	7.53	0.45
90	23.16	0.00	0.40



SP1A at COVE

The water-leaving radiance was measured at 9 elevation angles, 2, 12, 22, 32, 42, 52, 62, 72, and 90. For each elevation angle, SP1A scans 180 degrees of azimuth.

Data output rate is 4 to 5 per second. It needs approximately 4 minutes and 15 seconds to complete one set of measurements.

SP1A started to take data from May 2000 and continued from then on. Originally SP1A took data once every half an hour. But recently we changed it to every 5 minutes and average 6 times' measurements to give out the half-hour-averaged results.



Potential hazard



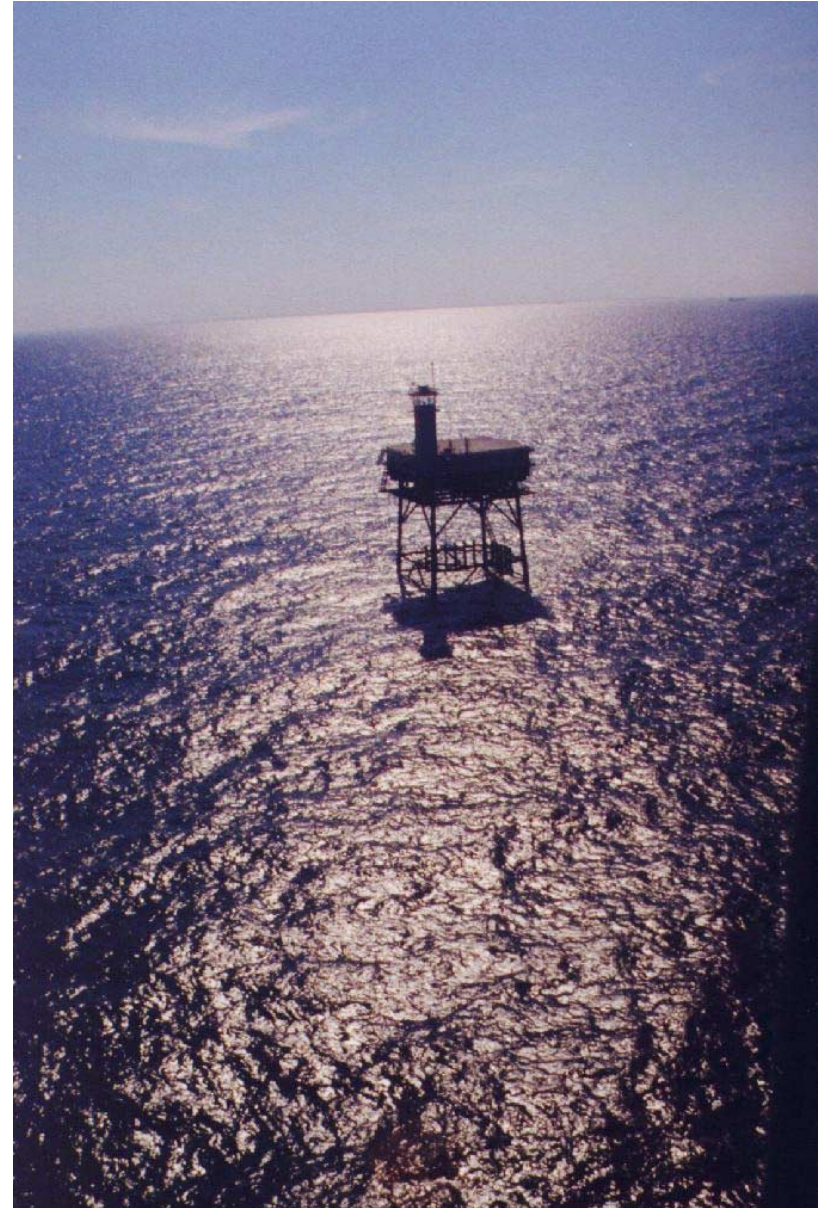
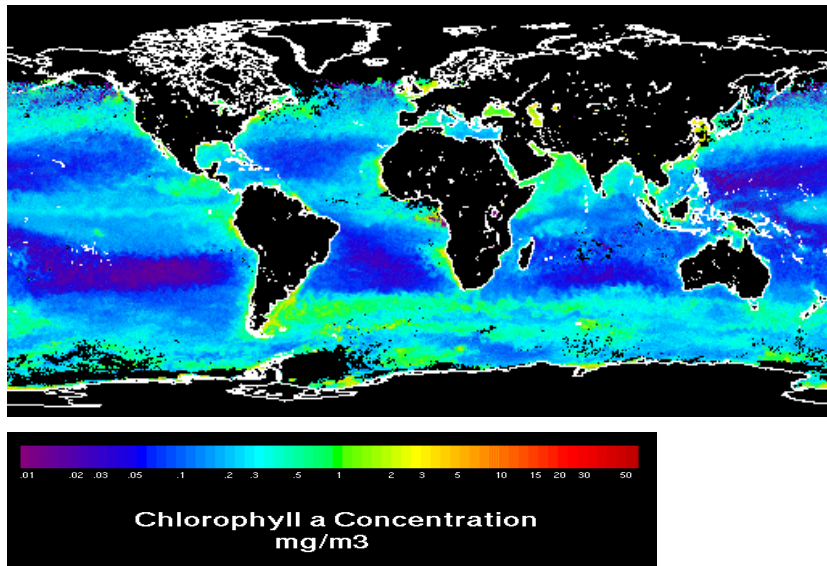
Ships inside the field of view, especially bright color ships, or airplanes and birds, can increase the measured water-leaving radiance dramatically. We plan to install camera or video camera at the lighthouse to help us to determine the reason of the sudden huge jumps in the data.



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Simulation of the water-leaving radiance

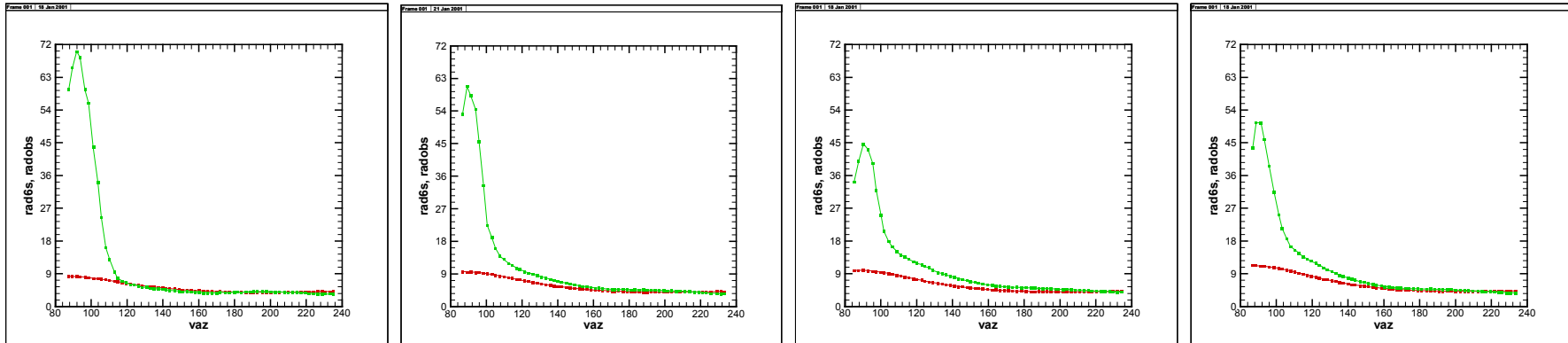
6S (Second Simulation of Satellite Signal in the Solar Spectrum) was used to calculate the water-leaving radiance to compare with our SP1A observations for clear skies conditions. Aerosol optical depths for COVE site were from AERONET. Pigment concentration was set as a constant, and sensitivity study shows that increase pigment concentration from 0.5 to 5 mg/m³, the change of the water-leaving radiance is within 1%. But we plan to use the SeaWiFS pigment concentration finally.



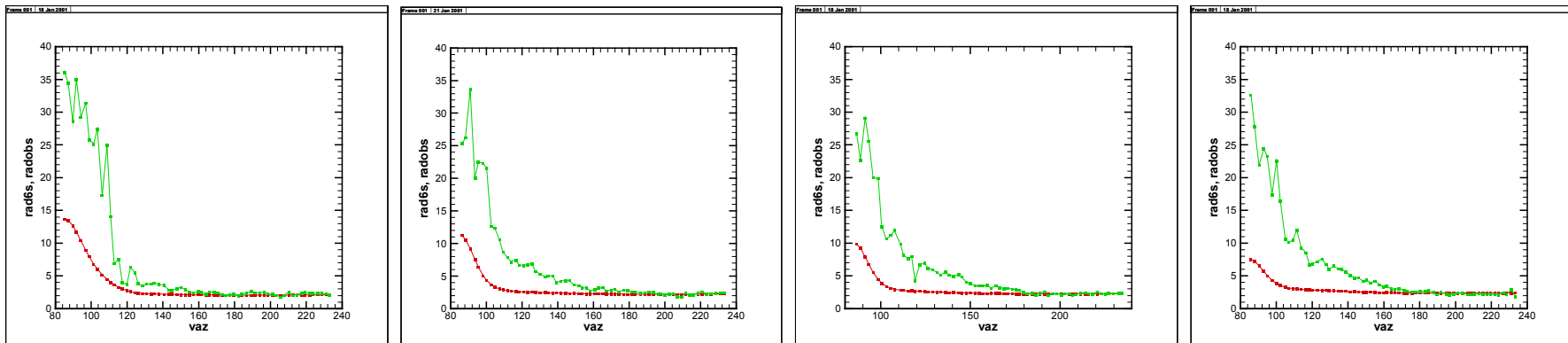
Comparison of observations and 6S simulations for 13 GMT

Solar Zenith Angle is 53.30~52.70, Solar Azimuth angle is 87.30~87.80 (± 180)

Elevation angle: 2



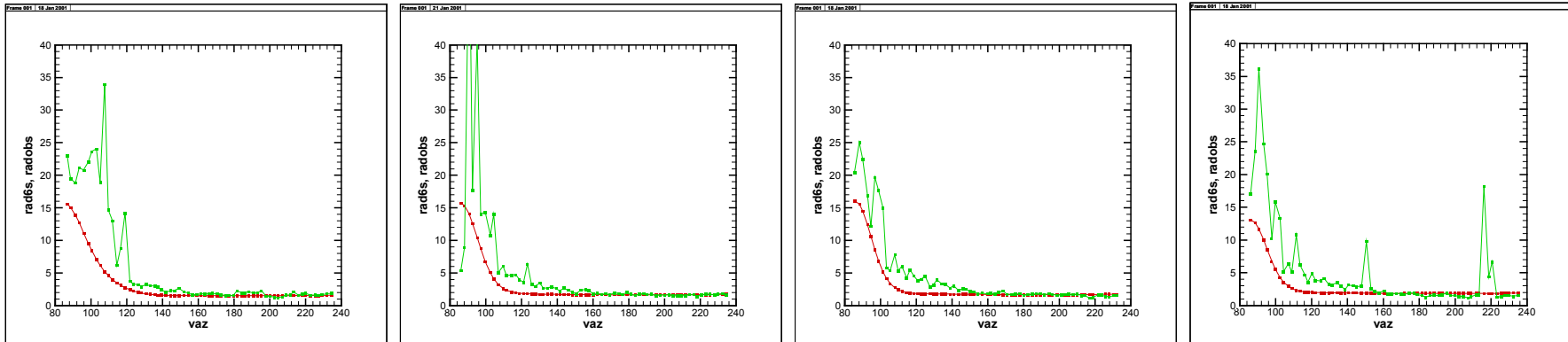
Elevation angle: 12



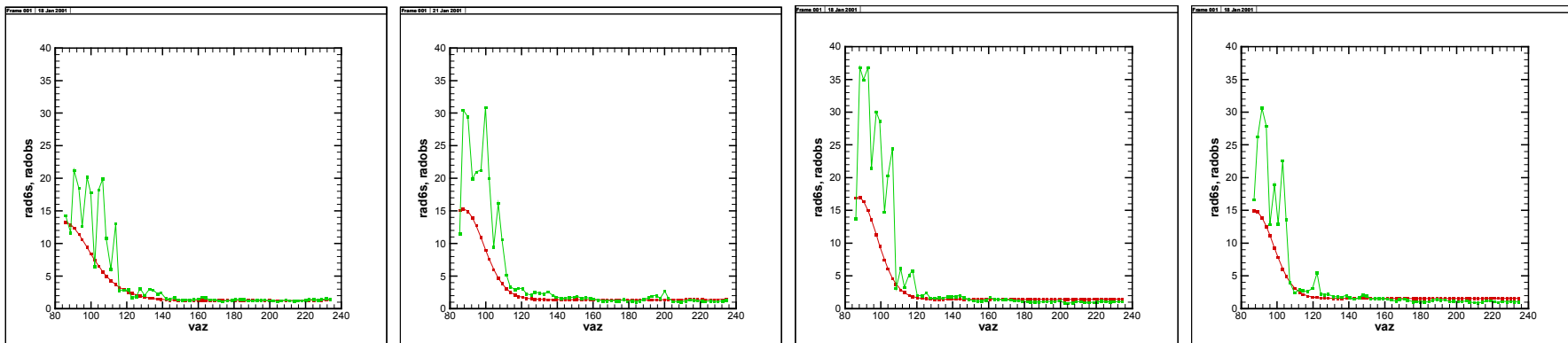
Comparison of observations and 6S simulations for 13 GMT (Con't)

Solar Zenith Angle is 53.30~52.70, Solar Azimuth angle is 87.30~87.80 (± 180)

Elevation angle: 22



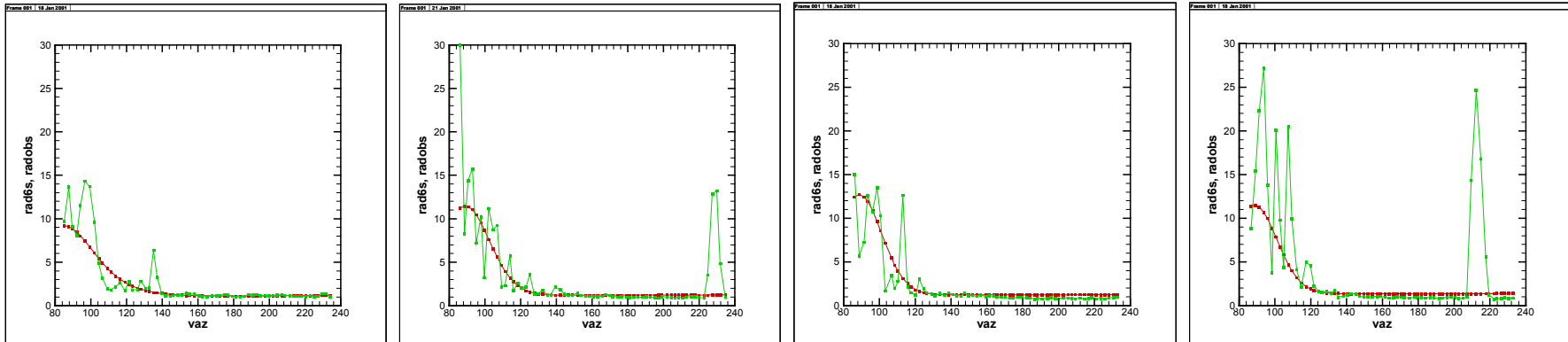
Elevation angle: 32



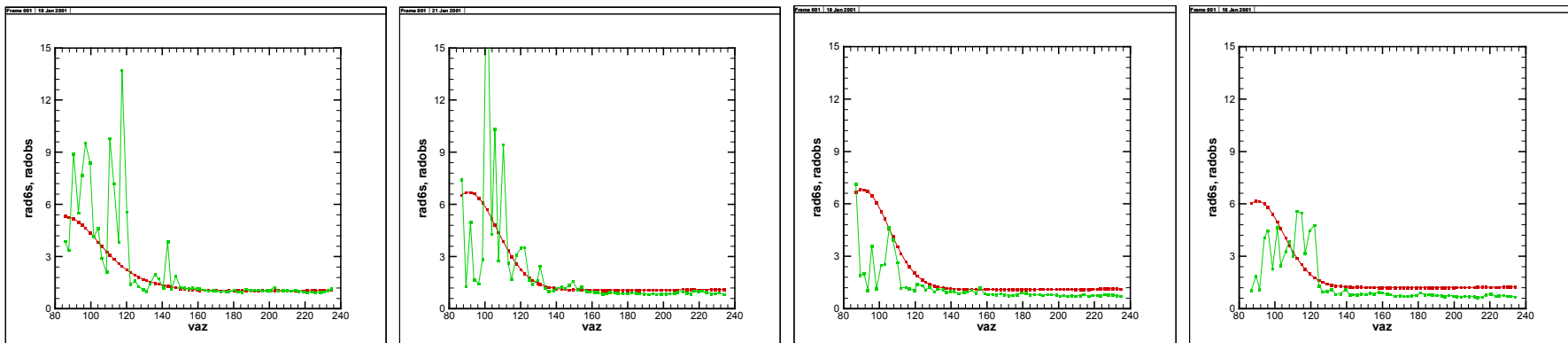
Comparison of observations and 6S simulations for 13 GMT (Con't)

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Elevation angle: 42



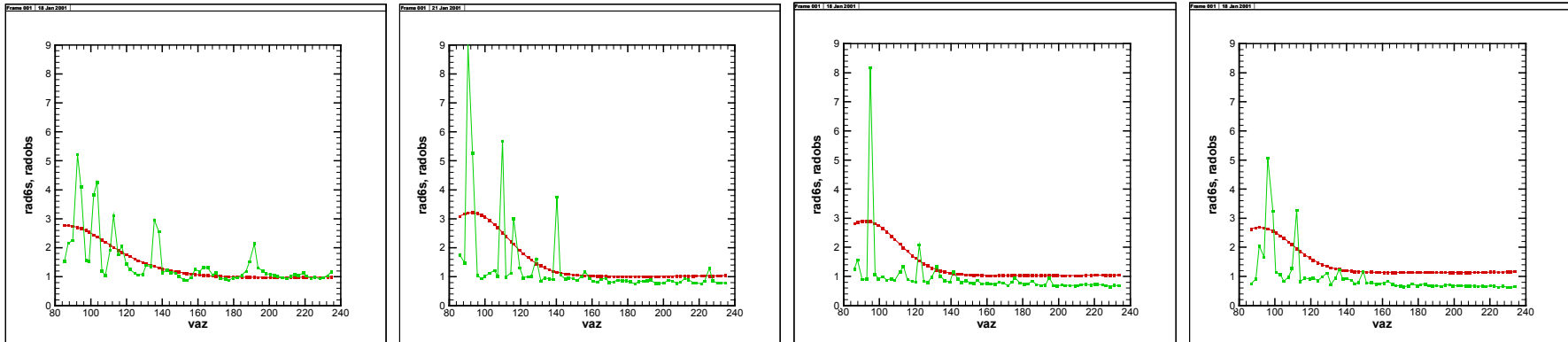
Elevation angle: 52



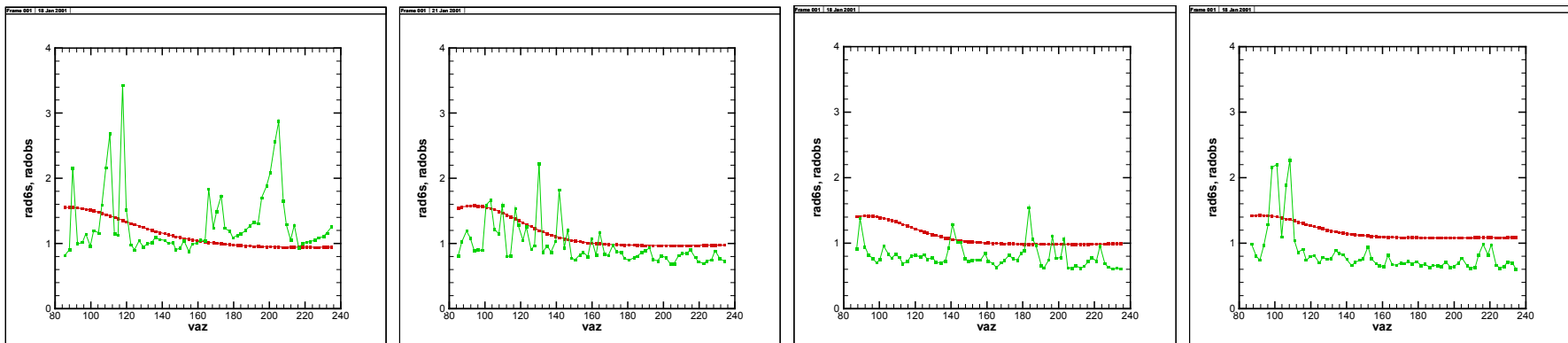
Comparison of observations and 6S simulations for 13 GMT (Con't)

Solar Zenith Angle is 53.30~52.70, Solar Azimuth angle is 87.30~87.80 (± 180)

Elevation angle: 62



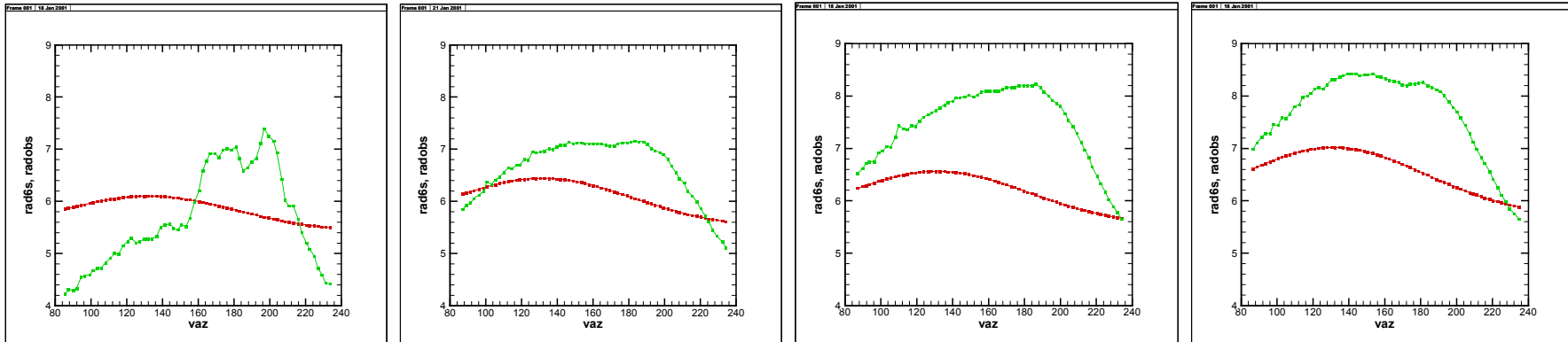
Elevation angle: 72



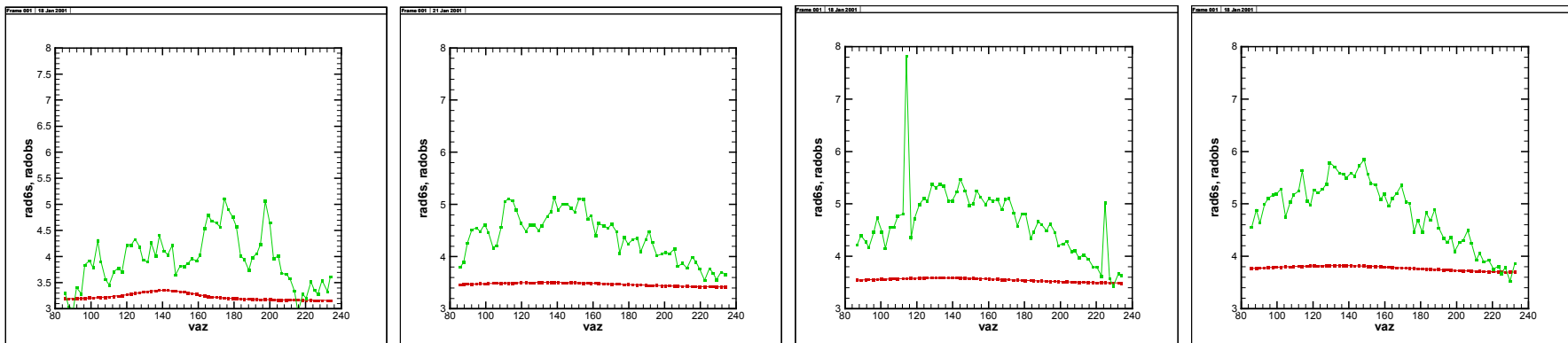
Comparison of observations and 6S simulations for 16 GMT

Solar Zenith Angle is 19.30~18.90, Solar Azimuth angle is 132.30~134.10 (± 180)

Elevation angle: 02



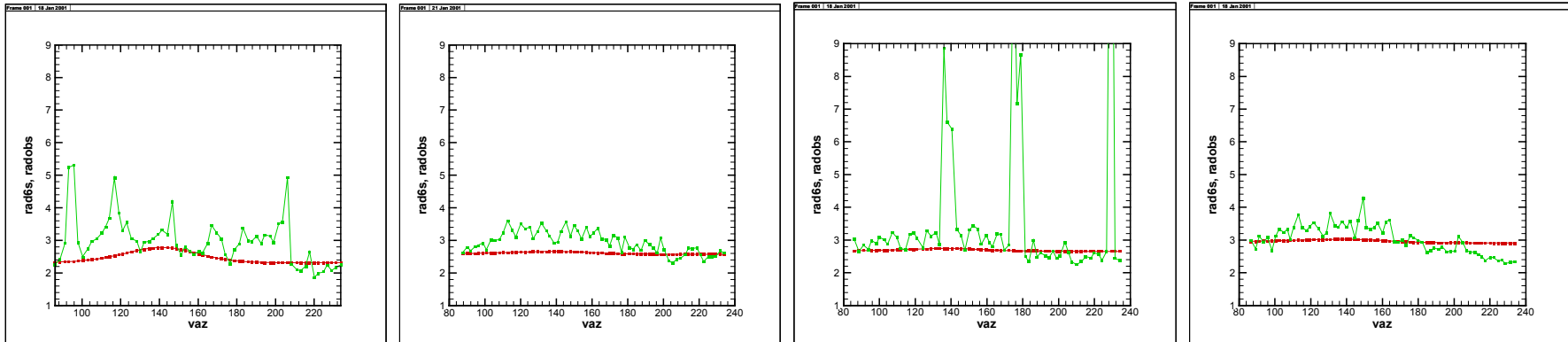
Elevation angle: 12



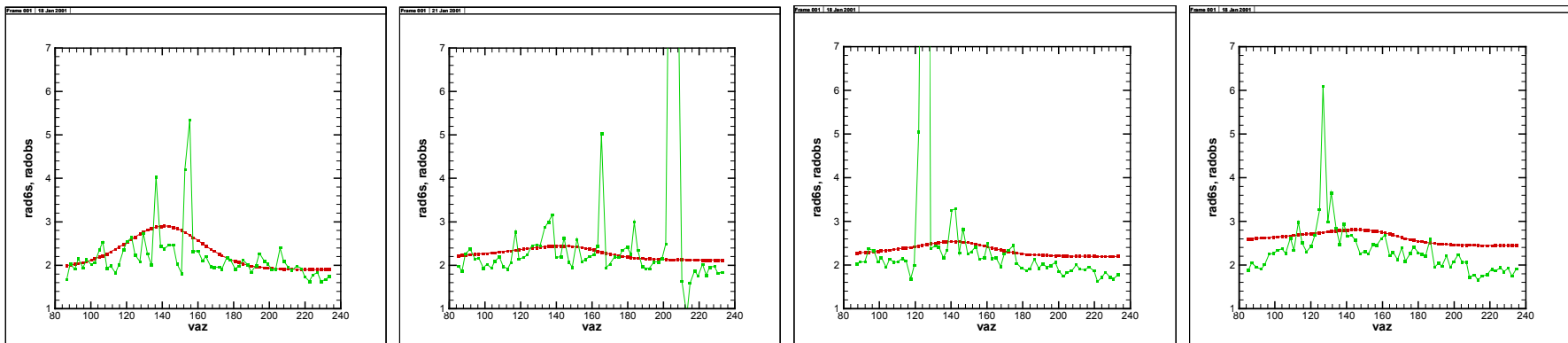
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Solar Zenith Angle is 19.30~18.90, Solar Azimuth angle is 132.30~134.10 (± 180)

Elevation angle: 22



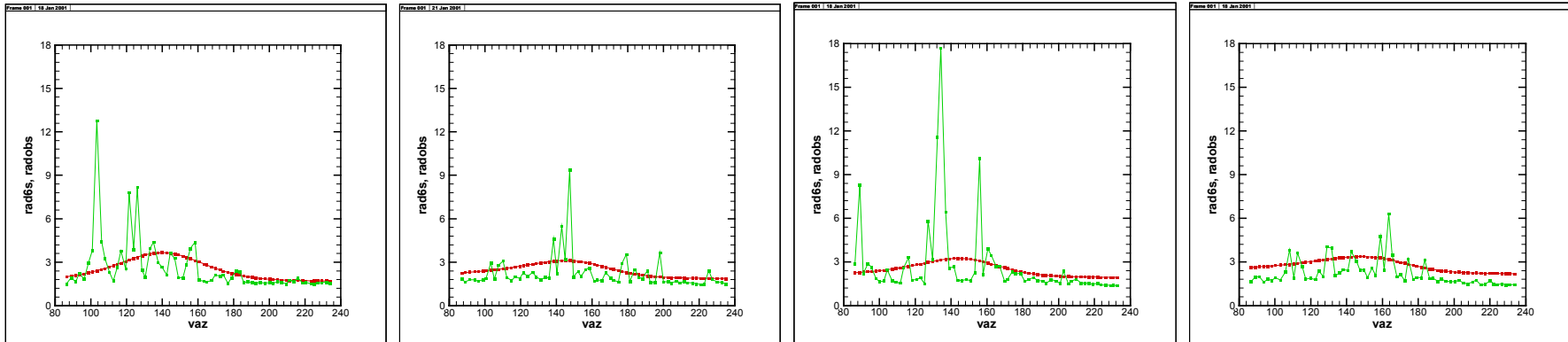
Elevation angle: 32



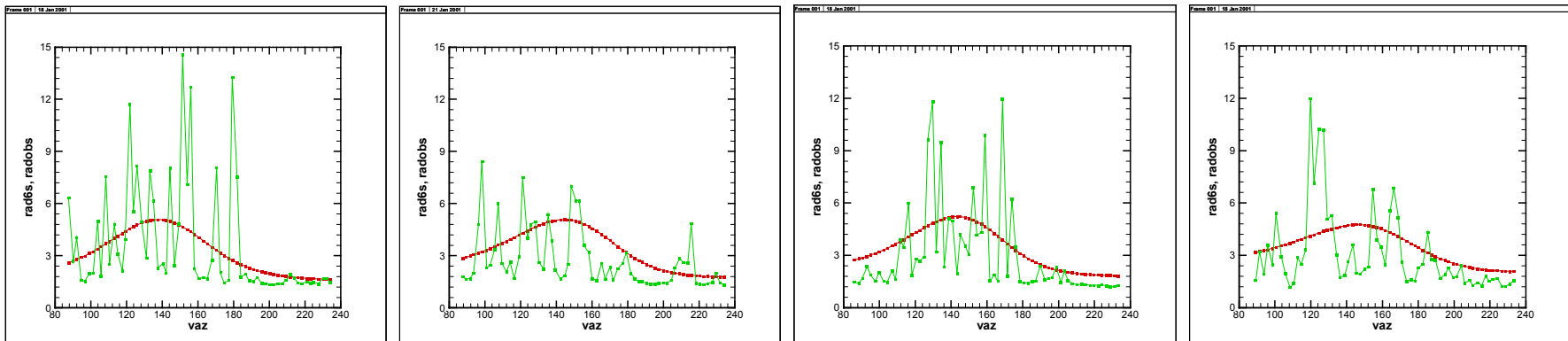
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Elevation angle: 42



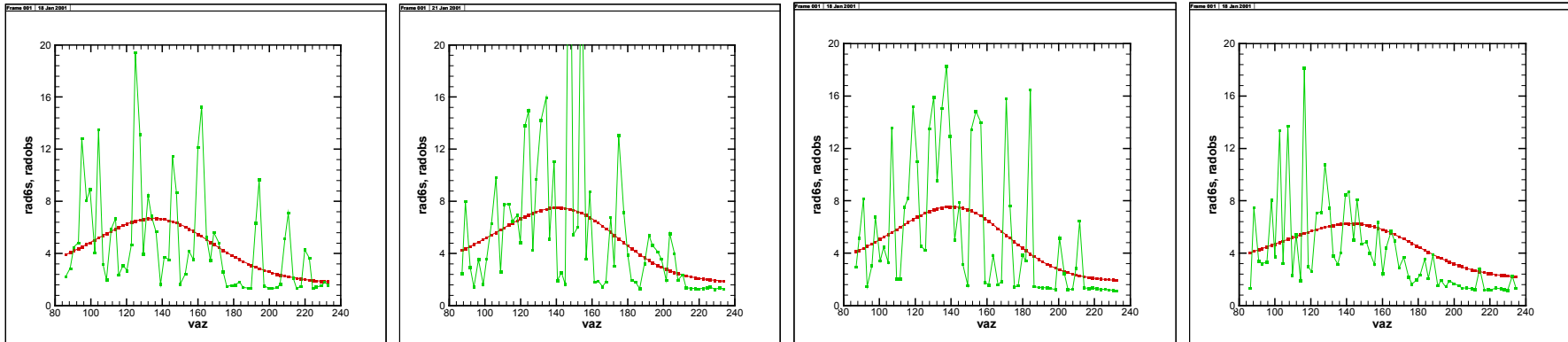
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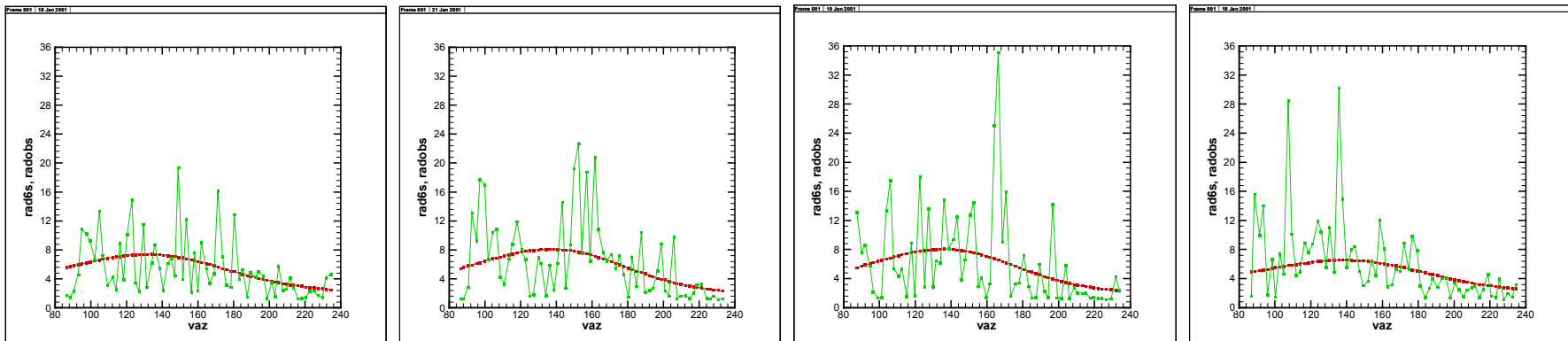
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Elevation angle: 62



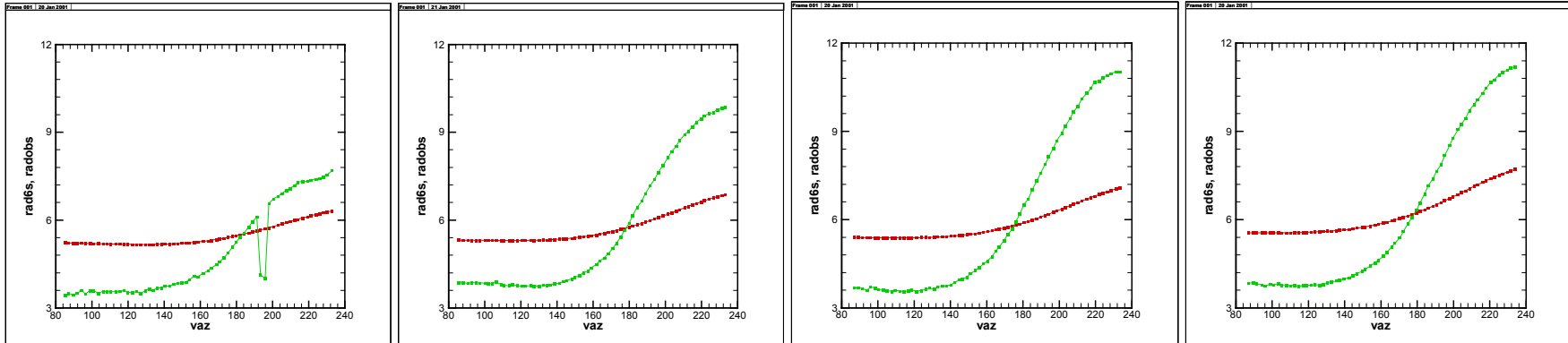
Elevation angle: 72



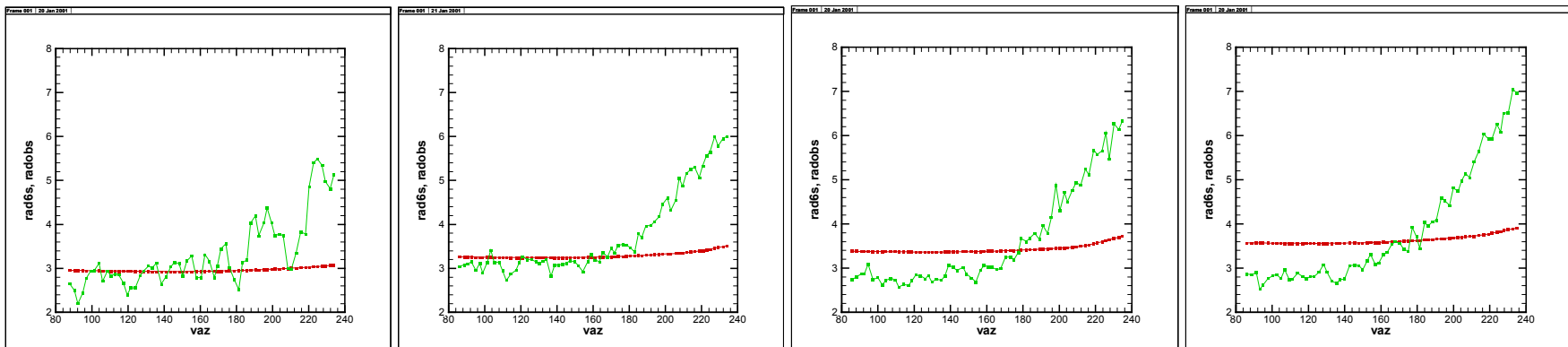
Comparison of observations and 6S simulations for 19 GMT

Solar Zenith Angle is 29.05~29.67, Solar Azimuth angle is 249.38~250.28 (± 180)

Elevation angle: 02



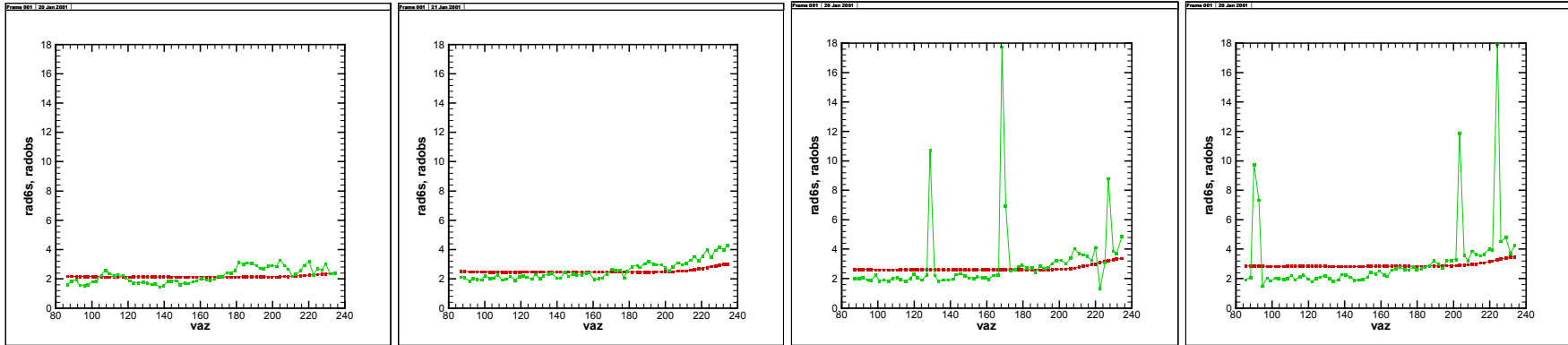
Elevation angle: 12



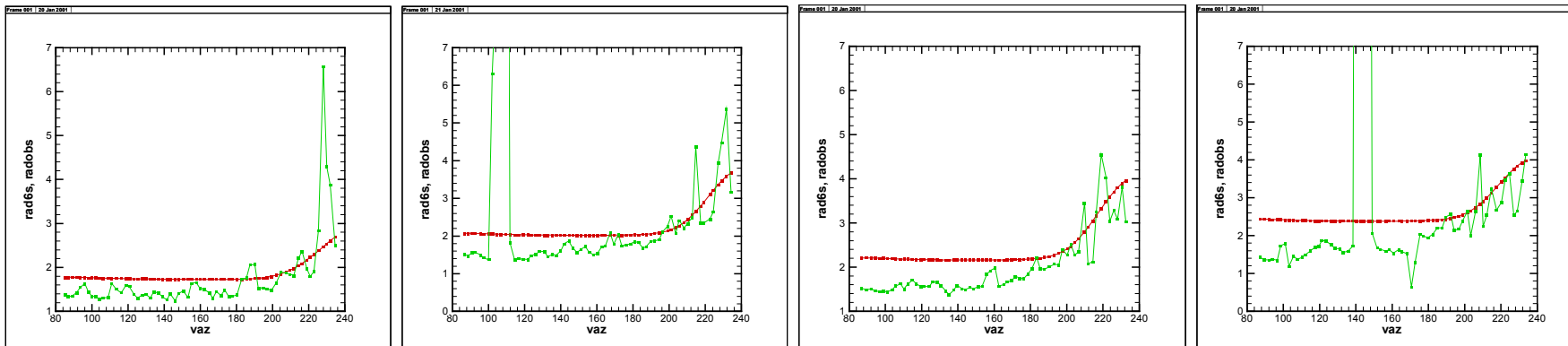
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Elevation angle: 22



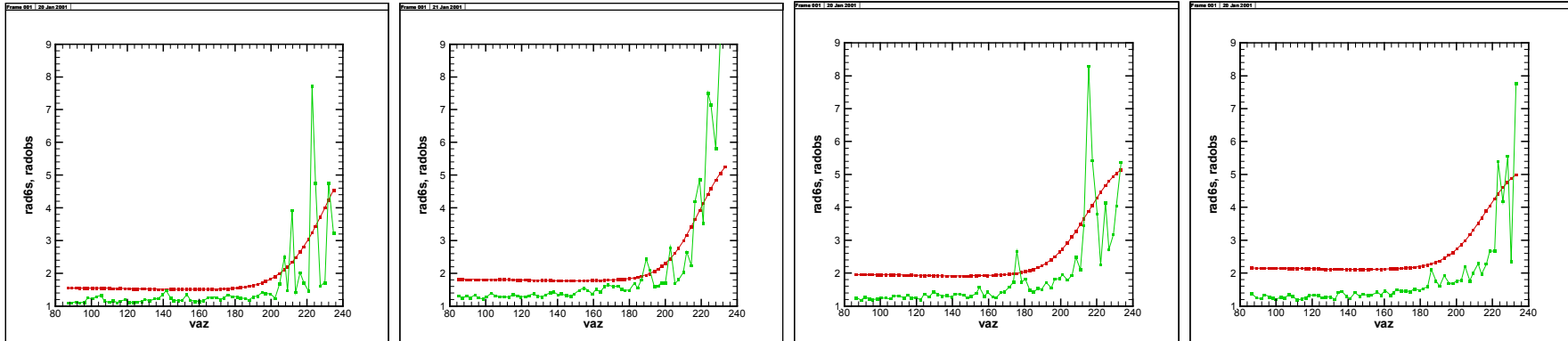
Elevation angle: 32



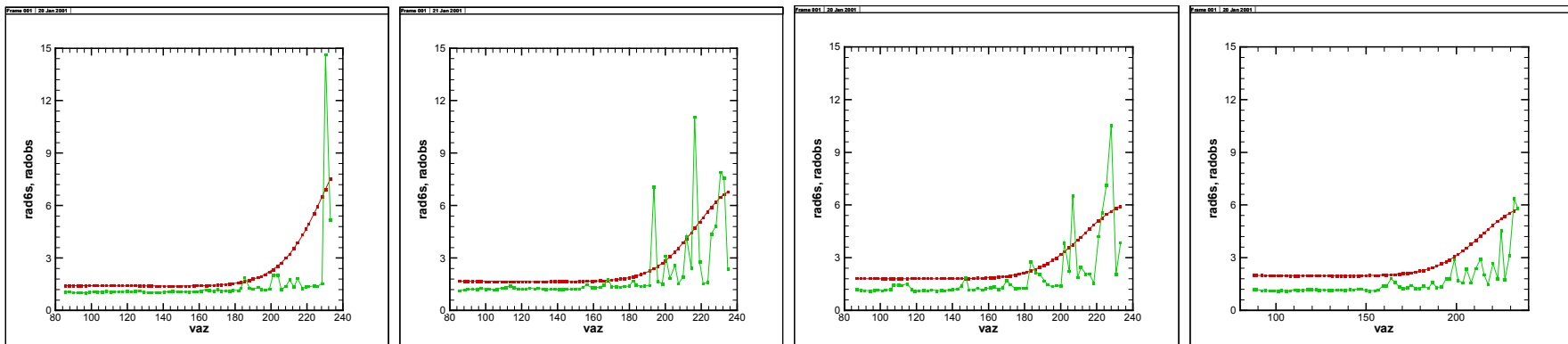
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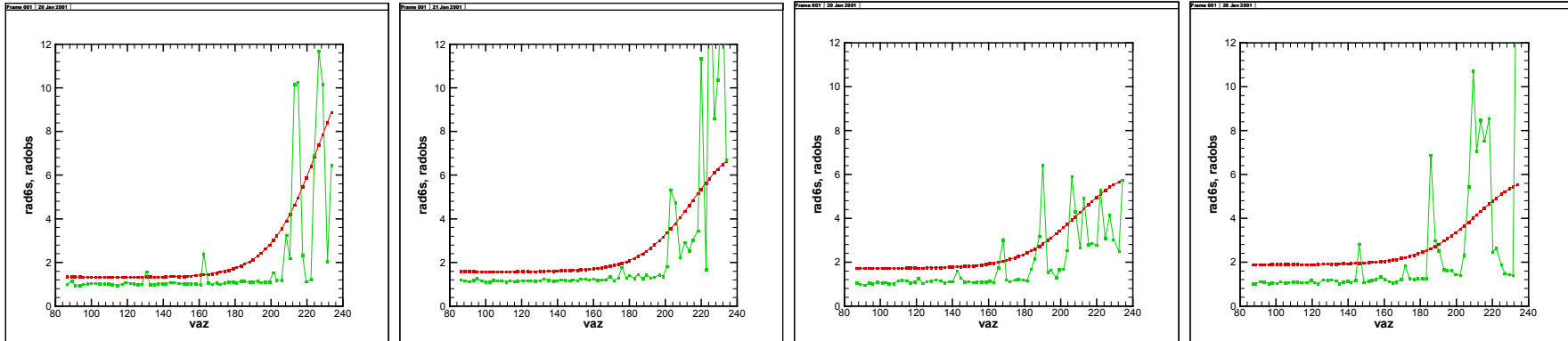
Elevation angle: 52



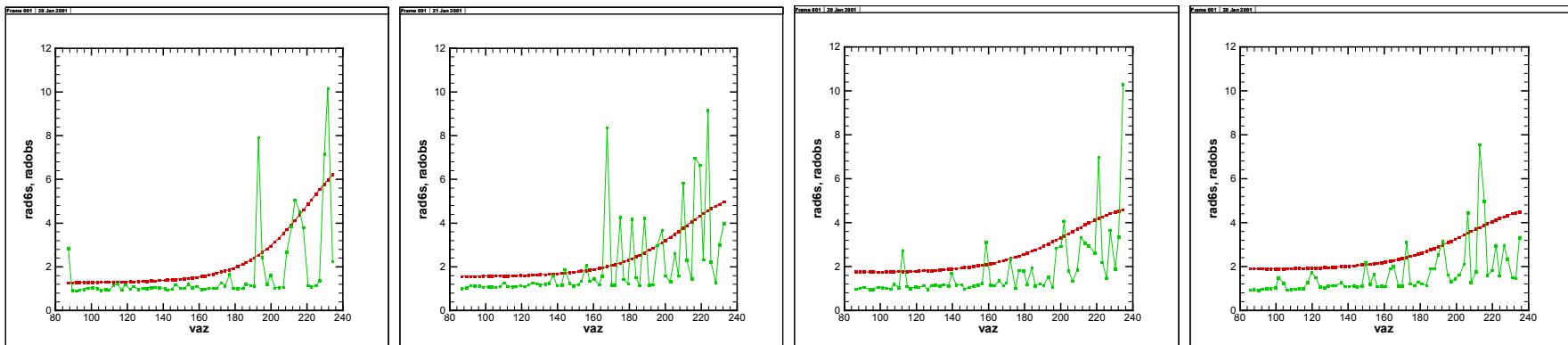
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Elevation angle: 62



Elevation angle: 72



Wind Speed and Wind direction data

Day	AOD	Time (GMT)	Wind Speed (m/s)	Wind Direction
159 (June 7)	0.132	13	12.1	2
		16	8.4	337
		19	5.3	337
		22	1.9	252
161 (June 9)	0.215	13	8.4	221
		16	6.9	197
		19	8.9	176
		22	11.2	170
162 (June 10)	0.243	13	7.0	215
		16	6.8	187
		19	11.4	175
		22	12.2	180
163 (June 11)	0.339	13	6.8	208
		16	8.6	200
		19	11.1	180
		22	11.8	176

*AOD: Aerosol Optical Depth at 500 nm (from AERONET at COVE)

*Wind direction measured clockwise from North



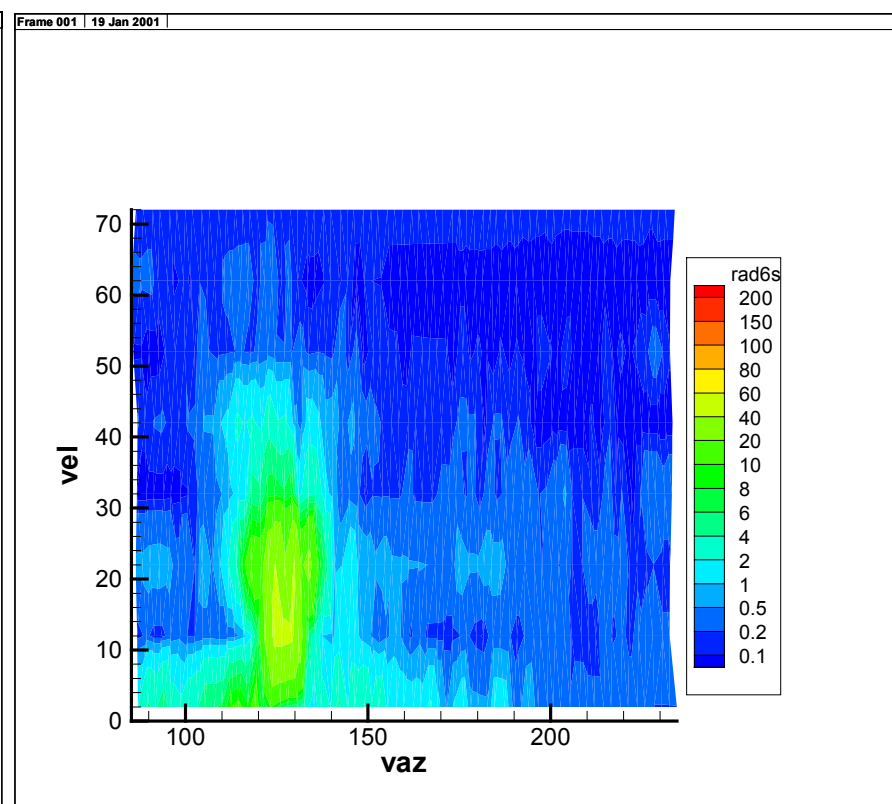
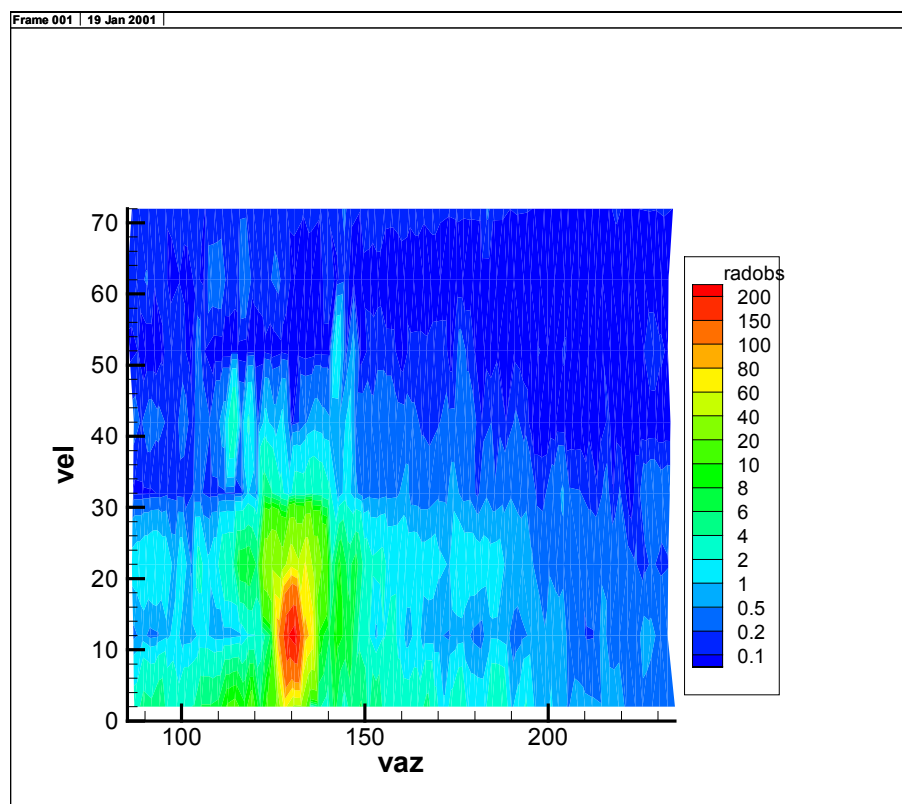
Radiance ($\mu\text{W}/\text{cm}^2/\mu\text{m}/\text{sr}$) for 2001-007 13GMT from 5-minute average.

SZA from 82.33 to 82.69, SAA from 124.45 to 124.99(± 180).

Average wind speed is 8.5 m/s and direction at 154.6. AOD is 0.151.

measurement

6S simulation



Radiance (uW/cm2/um/sr) for 2001-007 13GMT from 5-minute average.

SZA from 82.33 to 82.69, SAA from 124.45 to 124.99(± 180).

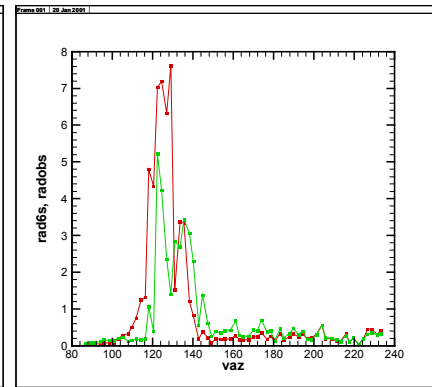
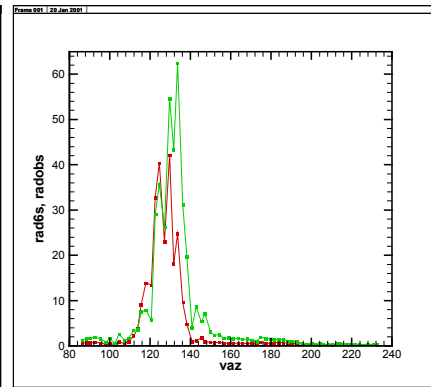
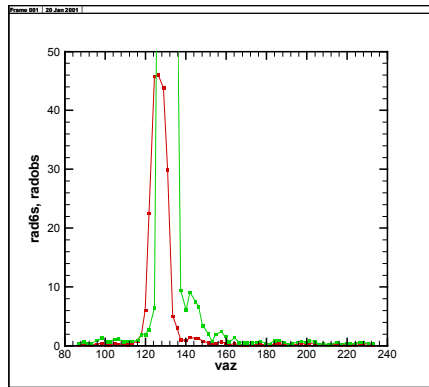
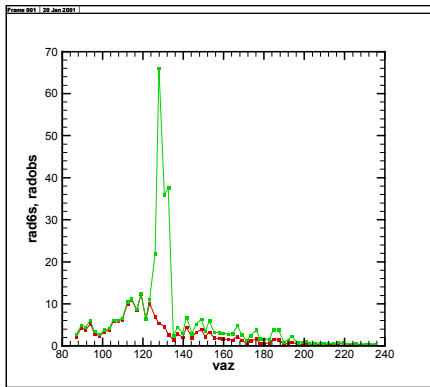
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02

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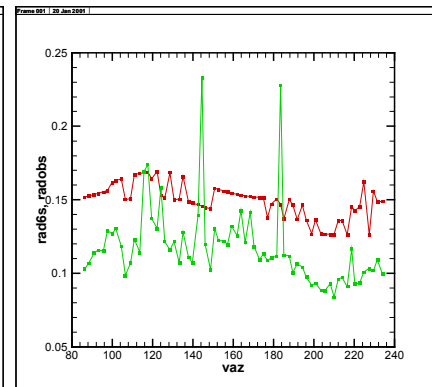
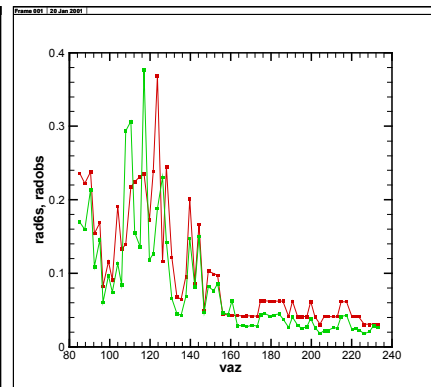
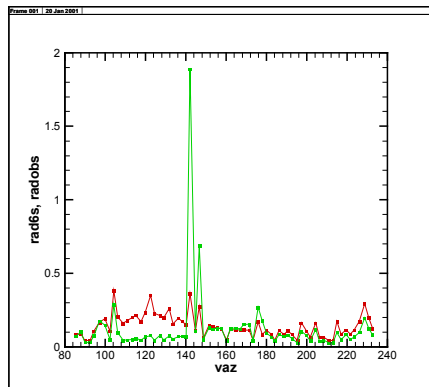
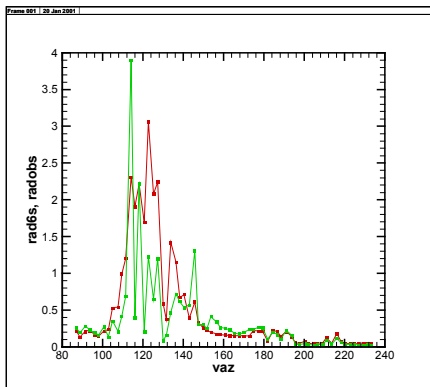


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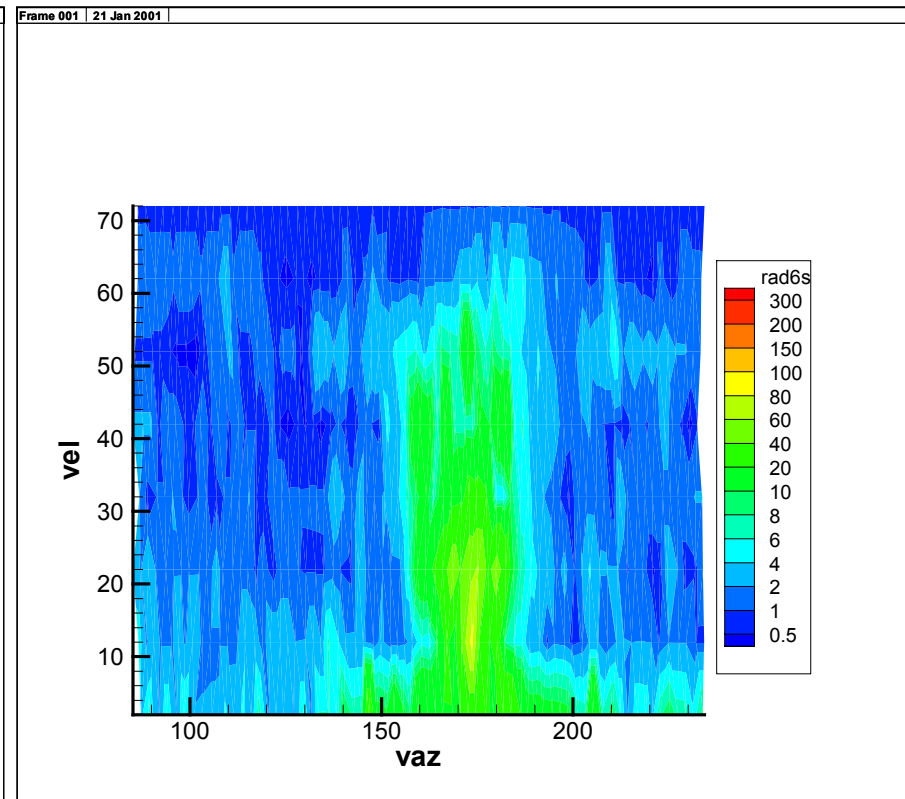
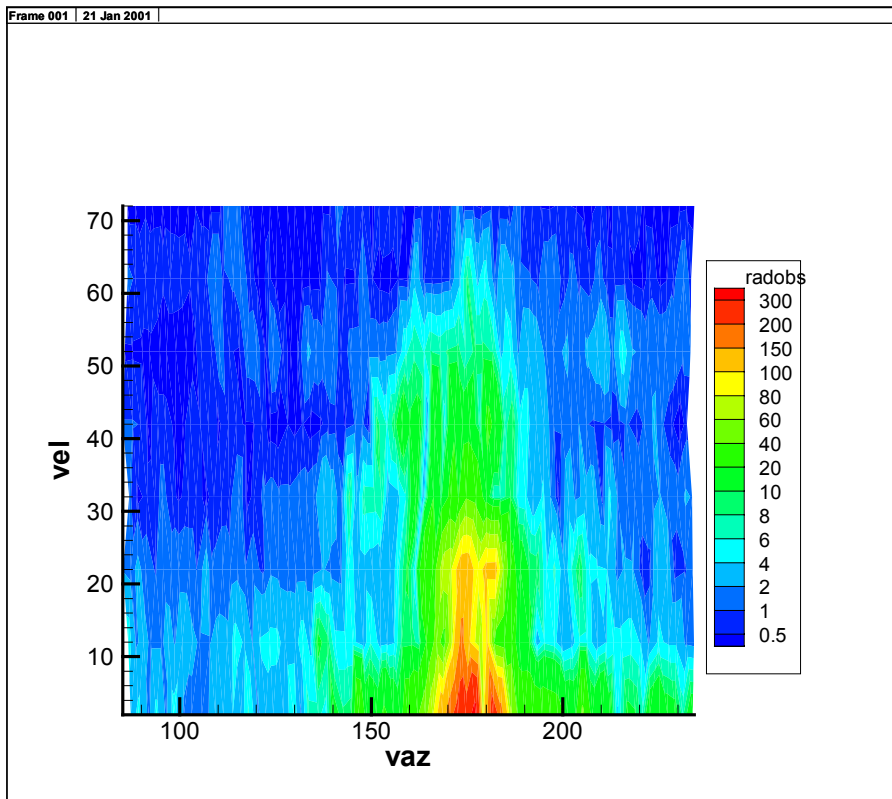
Radiance (uW/cm2/um/sr) for 2001-007 16GMT from 5-minute average.

SZA from 61.39 to 61.18, SAA from 161.72 to 162.56(± 180).

Average wind speed is 5.8 m/s and direction at 163.7. AOD is 0.151.

measurement

6S simulation



Radiance (uW/cm2/um/sr) for 2001-007 16GMT from 5-minute average.

SZA from 61.39 to 61.18, SAA from 161.72 to 162.56(± 180).

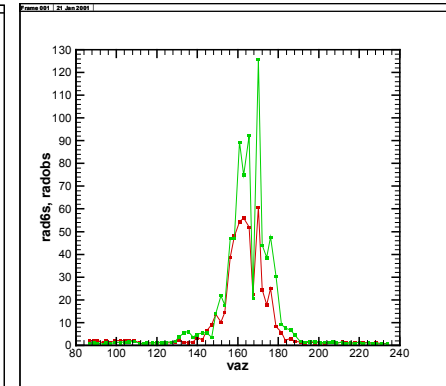
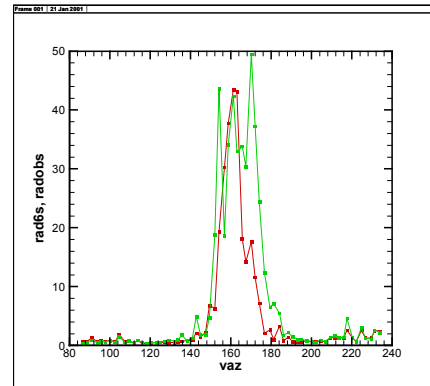
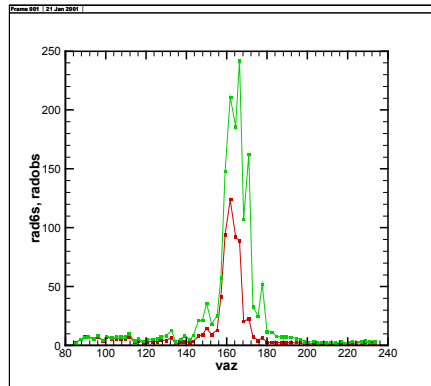
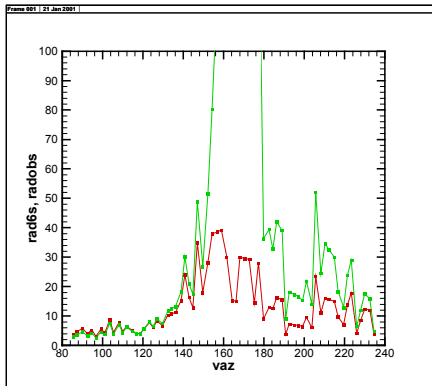
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02

12

22

32

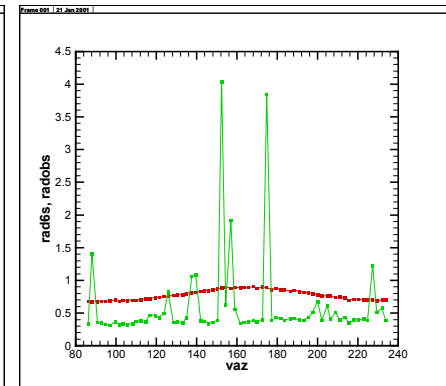
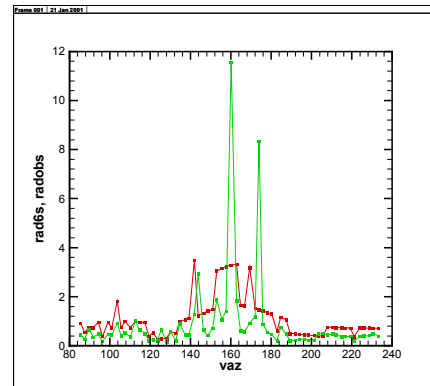
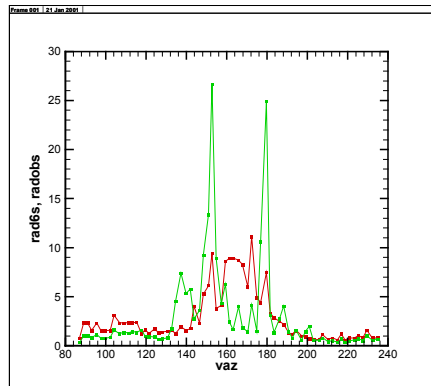
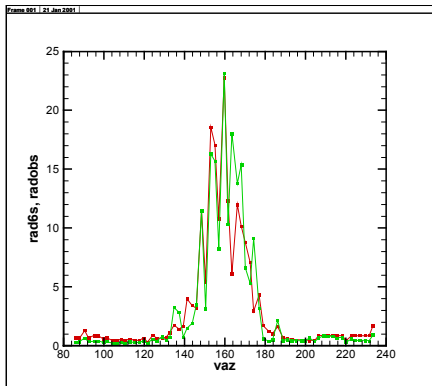


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72



Conclusions

- 1. The measured sun glint is more intense and covers a larger area than the Cox and Munk statistical results.**
- 2. Slope distribution is steeper than that predicted from Cox and Munk empirical relationship.**

Slope distribution may not only be a simple function of wind speed, but also related to the wave power spectrum densities (future work).
- 3. The water-leaving radiance distribution is also influenced by aerosol optical depth, the larger the aerosol optical depth the smoother the water-leaving radiance distribution is.**
- 4. Apart from the sun glint area, observed water-leaving radiance is smaller than model simulation. May cause by the strong absorption of coastal water.**
- 5. New 5-minute continuous measurement scheme yields better comparison than the old one, though limited data available now.**



ACE-Asia Cruise

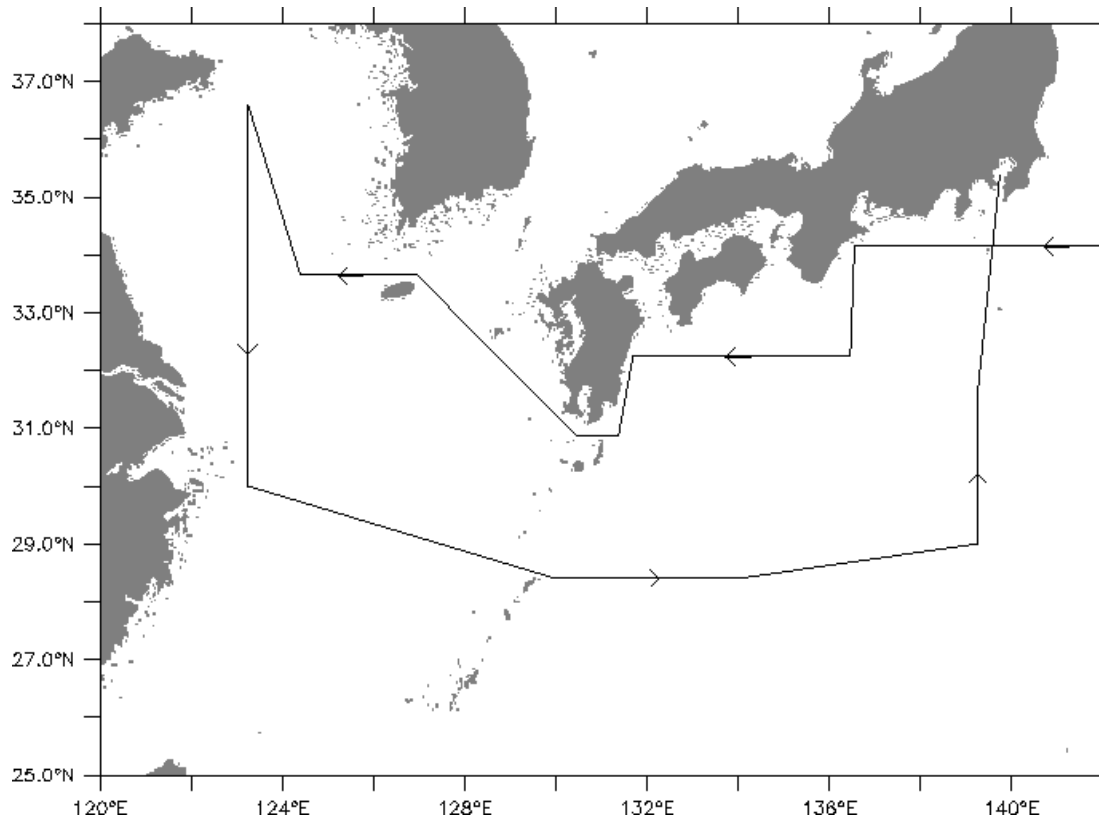
Schedule:

Arrive in Honolulu: 8-March 2001

Depart Honolulu, Hawaii: 14-March 2001 for a 38 day cruise

Arrive Yokosuku, Japan: 20-April 2001

Proposed Cruise Track



Measurement	Method	PI
Aerosol Chemical Measurements		
Aerosol Physical and Optical Measurements		
Radiation Measurements		
Aerosol optical thickness	Sky radiometer (Prede)	Frouin
Aerosol optical thickness	MicroTops	Quinn
Aerosol optical thickness	MicroTops	Frouin
Direct-beam normal irradiance, diffuse irradiance, total irradiance, aerosol optical thickness	Fast-rotating shadowband radiometer	Reynolds/Miller
Water leaving radiance	SIMBAD	Frouin
Water leaving radiance angular distribution	SP1A Spectrophotometer	Charlock/Su
Sky images & cloud fraction	Total Sky Imager	Reynolds, Miller
Irradiance	Kipp & Zonen Pyranometer (Global on gimbals): Two; one broad band and one filtered for visible. BSI-Photo-Diode radiometer (with 5 channels): One global on gymbal. ASD spectral radiometer (global)	Flatau
Atmospheric Trace Gas Measurements		
Seawater Measurements		
Meteorological Measurements		





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