



Pre-Operational Assimilation Testing of SSMIS

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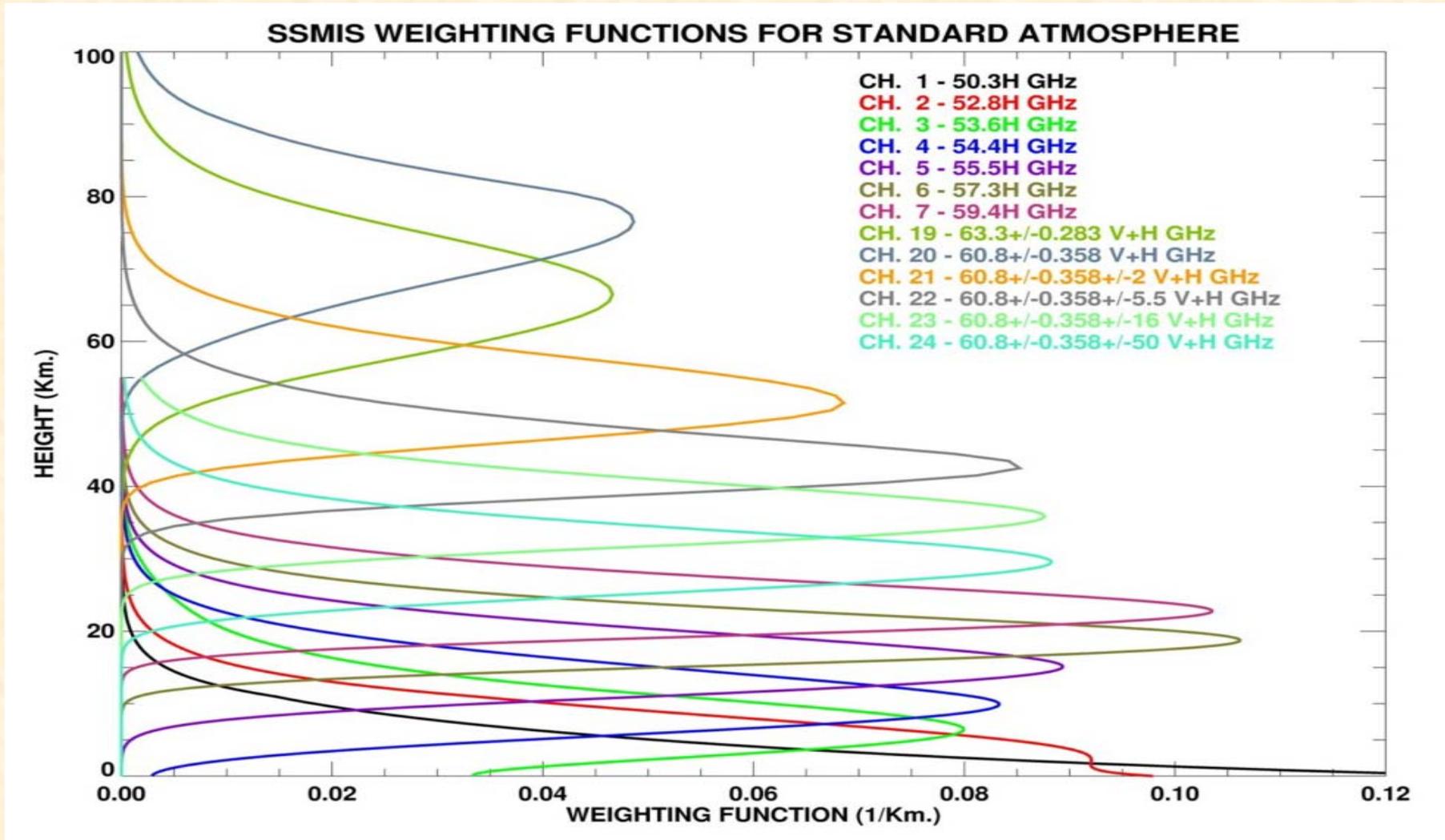
Special Sensor Microwave Imager/Sounder (SSMIS)



- The first **SSMIS** instrument was successfully launched on October 18th, 2003, aboard the Defense Meteorological Satellite Program satellite F16 (DMSP-F16)
- **SSMIS** is a conically-scanning passive microwave radiometer that includes seven temperature sounding channels peaking below 30 Km, and seven peaking between 30 Km and 80 Km, along with imaging channels from the heritage SSMI instrument
- The tropospheric and stratospheric temperature sounding channels are similar to those of the **AMSU-A** instrument aboard NOAA satellites 15-18, which have tremendous positive impact on numerical weather prediction (NWP) systems
- The **AMSU-A** instruments have cross track scanners, as opposed to the conically-scanning **SSMIS**. The utility of conical sounders for NWP has been debated – results of our tests so far warrant cautious optimism.



SSMIS Weighting Functions



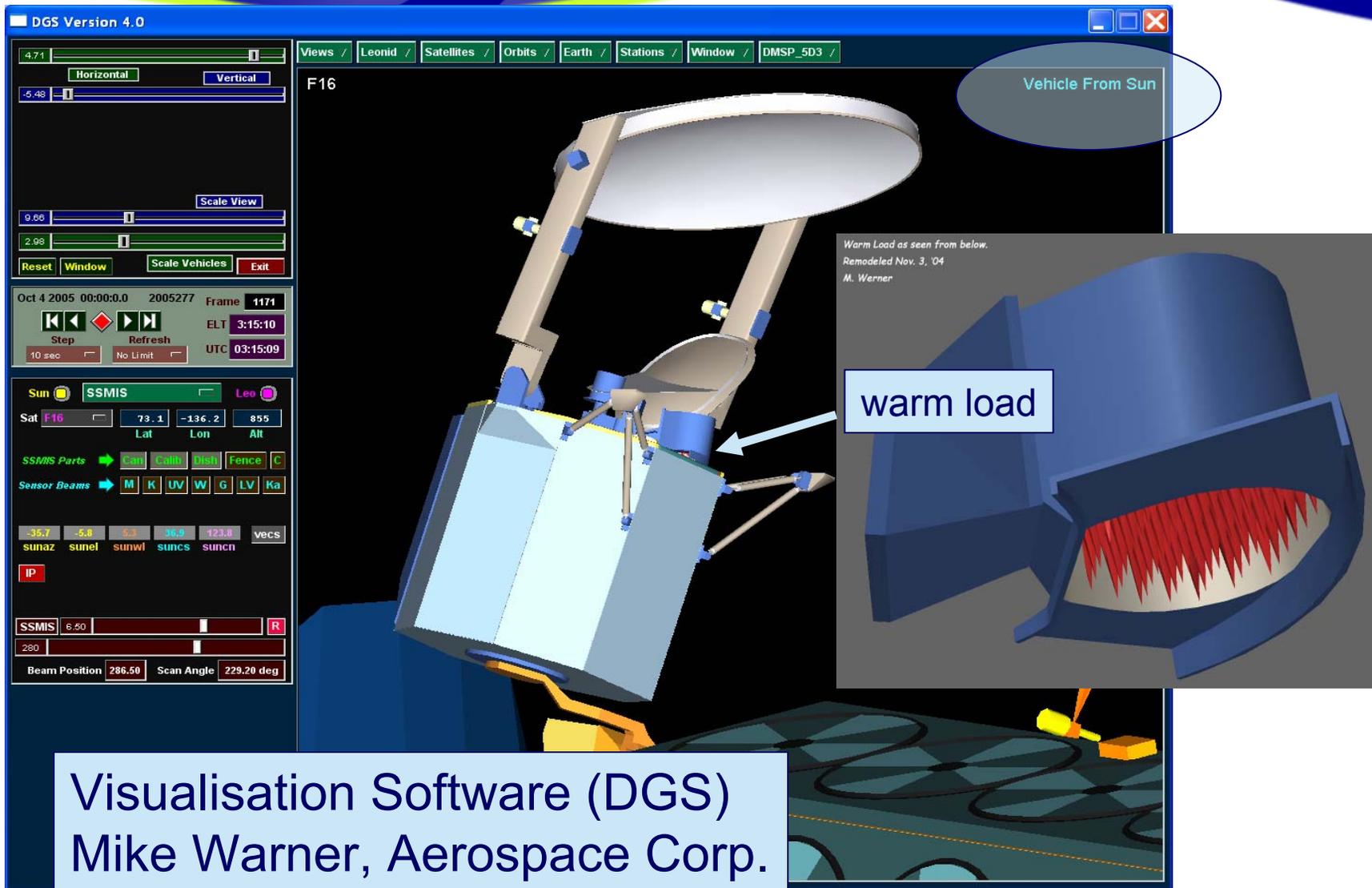


Calibration Issues: Warm Load Intrusion



- Two calibration anomalies were discovered by the SSMIS Cal/Val team
- The first anomaly is a **warm load intrusion**, which affects 30-40% of the data, depending on time of day and season
- Several times per day, direct or reflected **sunlight heats the warm calibration target**, increasing the apparent gain, and **resulting** in anomalously **cool observations**
- Because of the tight tolerances for error for radiance assimilation, we must either correct this data, or discard it
- Mitigation strategy
 - Met Office
 - Data is flagged and not used
 - NRL
 - Gain time series is Fourier filtered, resulting in a usable “corrected gain” except when the heating rate is very high and data is discarded
 - Currently, all data in ascending orbit is flagged and not used

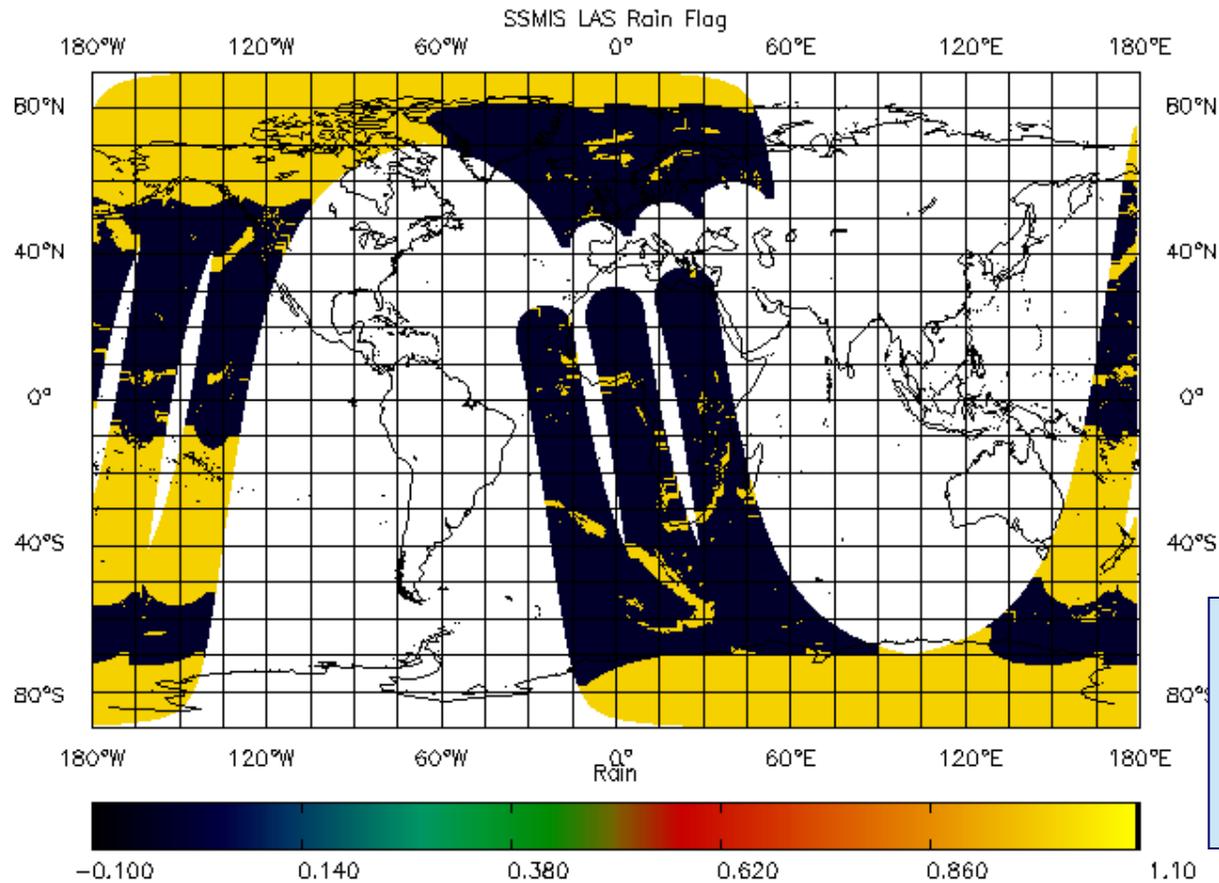
Instrumental Biases: warm load solar intrusions



The image shows a screenshot of the DGS (Data Ground Station) software interface, version 4.0. The main window displays a 3D model of a satellite, labeled 'F16', with various instruments and antennas. A callout box labeled 'Vehicle From Sun' points to the satellite. An inset window titled 'Warm Load as seen from below.' shows a detailed view of a warm load, which is a red, serrated structure inside a blue container. A callout box labeled 'warm load' points to this inset. The software interface includes a top menu bar with options like 'Views', 'Leonid', 'Satellites', 'Orbits', 'Earth', 'Stations', 'Window', and 'DMSP_5D3'. The left sidebar contains various controls, including sliders for 'Horizontal' and 'Vertical' views, a 'Scale View' slider, and buttons for 'Reset', 'Window', 'Scale Vehicles', and 'Exit'. The bottom left corner of the interface shows the 'SSMIS' (Scanning Multichannel Microwave Radiometer) instrument settings, including 'Sat F16', 'Lat 73.1', 'Lon -136.2', 'Alt 855', and 'Beam Position 286.50'.

Visualisation Software (DGS)
Mike Warner, Aerospace Corp.

Intrusion flagging: coverage



Yellow : rejected

Black: OK

(30 - 40% data flagged)

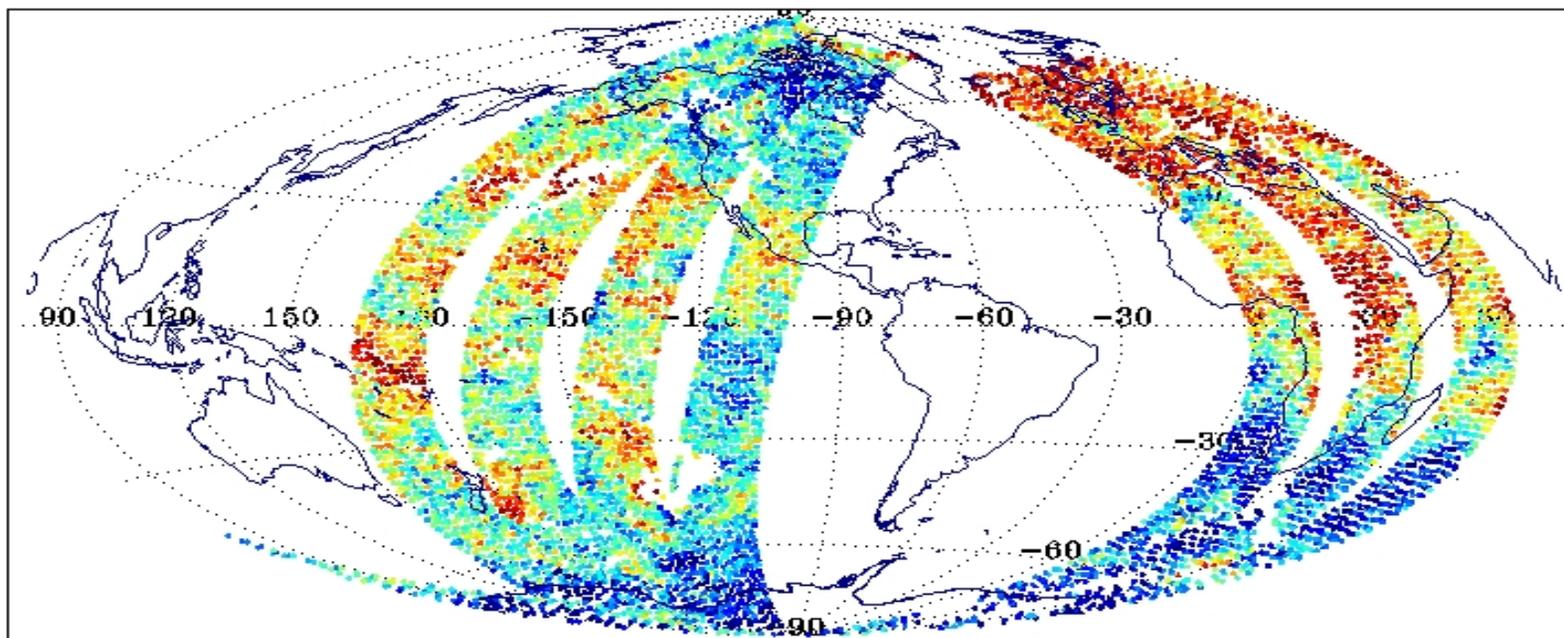


Descending Node Pattern



DMSF F-16 SSMIS Initial ECGCOB-BK Ch. 4 54.4 GHz H
DTG: 2005112118

No. Scenes:	8612	Min	0.09	MEAN	0.92
		Max	1.69	SDEV	0.27



Left half (descending, in sunlight) look like normal innovations
Right half (ascending, in shadow) has a pronounced NH/SH pattern





Calibration Issues: Reflector Emission



- The second anomaly is a **reflector emission**
- The temperature of the **main reflector** varies between 220 and 300 K during orbit, and the **anomalous emissivity** of 0.01 to 0.05 **contaminates the scene temperature**
- Mitigation strategy
 - Met Office
 - Construct an empirical reflector temperature from measurement of the reflector arm temperature.
 - Estimate the emissivity in each channel by fitting to computed innovations
 - Compute a correction, which is the emissivity times the reflector temperature
 - NRL
 - Similar estimate of reflector temperature, but uses channel-independent estimate of emissivity
 - Correction for outgoing longwave radiation when sensor is in Earth's shadow
- Poster A12 has more details on the SSMIS calibration



Met Office Assimilation Tests



- **Preprocessing**
 - Reflector emission correction, intrusion flagging, footprint averaging (50km gaussian convolution to reduce $NE\Delta T$ from $\sim 0.3K$ to $0.1K$), Ch 2-3 over ocean only, observation error set to $0.5K$ in Ch 2-4, (approximately double that of comparable AMSU-A radiances), $1.0K$ in Ch 5-7, and $2.0K$ in Ch 23, reject ALL channels if there are large innovations in channel 2 ($> 0.6K$), traditional air-mass bias correction (2-predictor Harris & Kelly method), standard QC checks, thinning to $\sim 4,000$ obs/channel/6 hr window
- **Channels**
 - Channels 2-7 and 23 (all peak below 40 Km)
- **Time period**
 - One month (December 12th, 2005 – January 11th, 2006)
- **Assimilation system**
 - operational configuration: 3DVar, 3 AMSU instruments plus AIRS, SSMI windspeeds, feature-track winds and scatterometer winds (Quikscat and ERS-2)
- **Radiative transfer model**
 - RTTOV-7, 43 levels to 0.1 hPa
- **Forecast model**
 - Met Office Unified Model, N216 horizontal resolution, 50 levels to 0.1hPa



Met Office Assimilation Tests



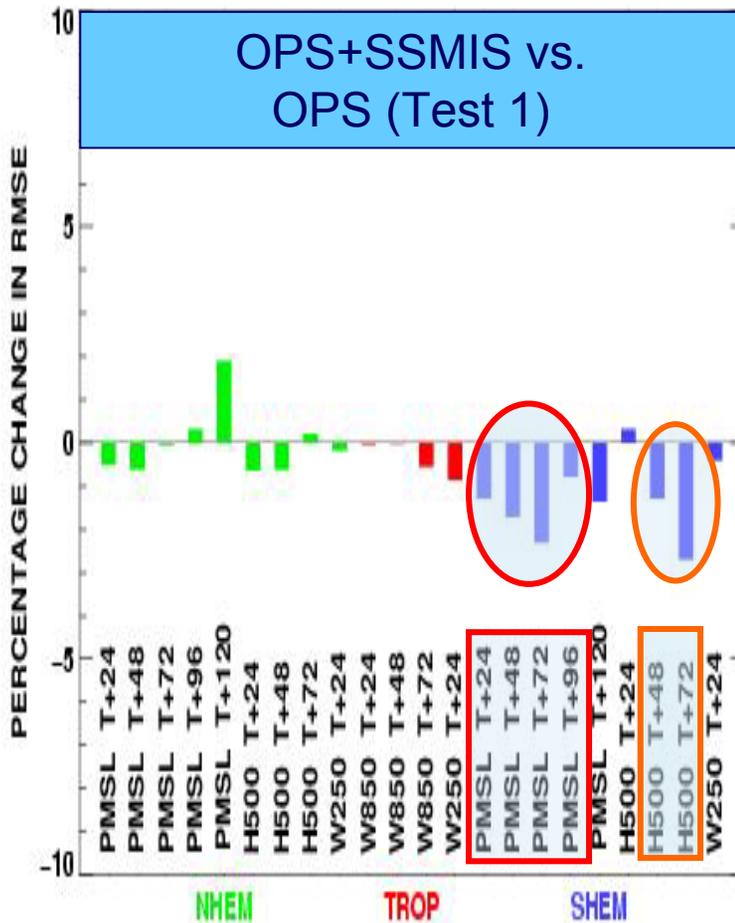
- Test 1: **Ops + SSMIS** vs. **Ops**
 - The purpose of test 1 is to evaluate whether the addition of SSMIS radiances to a full operational system enhances NWP forecasts.
- Test 2: **Ops + SSMIS - NOAA15 AMSU-A/B** vs. **Ops - NOAA15 AMSU-A/B**
 - The purpose of test 2 is to evaluate the performance of SSMIS as a risk reduction sensor, in case of failure of one or more NOAA satellites before the launch of NPP/NPOESS satellites. NOAA15 is the oldest satellite with AMSU-A, and is in a similar orbit to DMSPF16.

MO 3DVar N216 trials : winter 2005/06



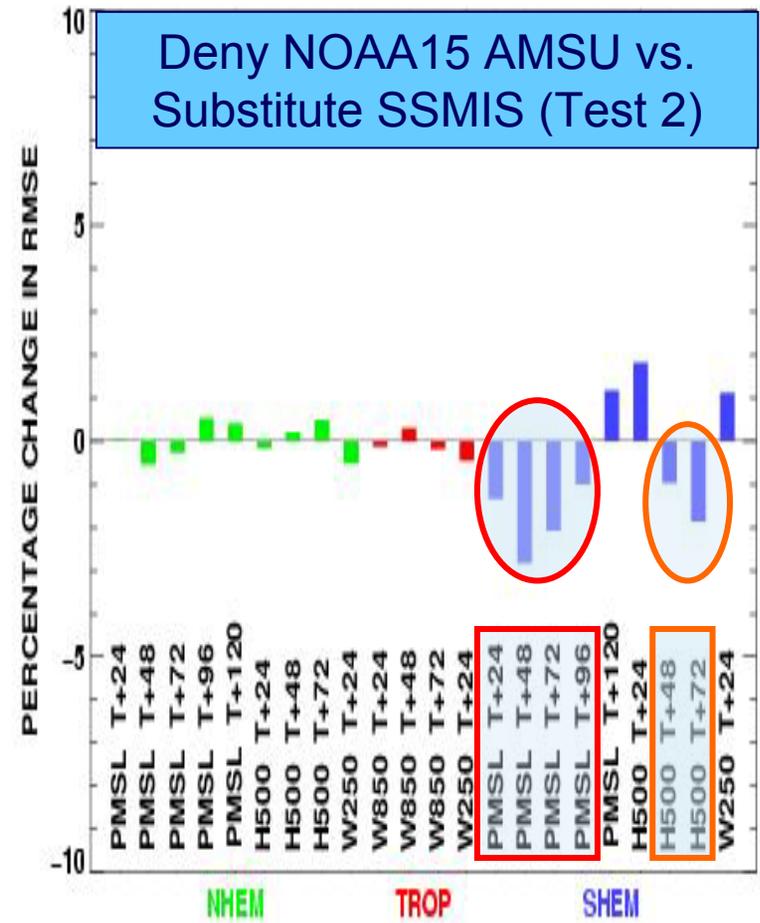
VERIFICATION VS OBSERVATIONS

OVERALL CHANGE IN NWP INDEX = 0.390



VERIFICATION VS OBSERVATIONS

OVERALL CHANGE IN NWP INDEX = 0.240





NRL Assimilation Tests

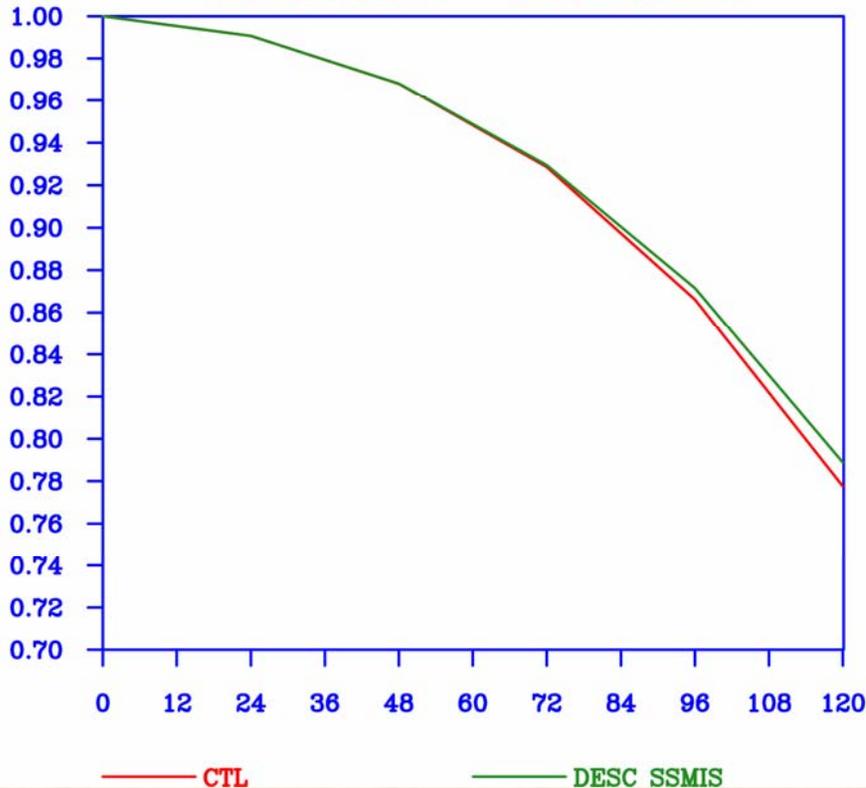
- **Preprocessing**
 - Reflector emission correction, gain correction for intrusions, Ch 2 over ocean only, observation error set to 0.5K in all channels, traditional air-mass bias correction (2-predictor Harris & Kelly method), standard QC checks, use descending orbits only, thinning to ~4,000 obs/channel/6 hr window
 - From 11/28 onward: ch 2 innov > 0.6K check, ob error in ch 5-7 set to 1.0K
- **Channels**
 - Channels 2-7 (all peak below 30 Km)
- **Time period**
 - Two months (November 8th, 2005 – December 31st, 2005)
- **Assimilation system**
 - operational configuration: 3DVar, 3 AMSU-A instruments plus SSMI windspeeds and total precipitable water, feature-track winds and scatterometer winds (Quikscat and ERS-2), no AIRS, no AMSU-B
- **Radiative transfer model**
 - CRTM, 30 layers, top layer centered at 4 hPa
- **Forecast model**
 - NOGAPS, T239 horizontal resolution, 30 vertical levels to 4 hPa



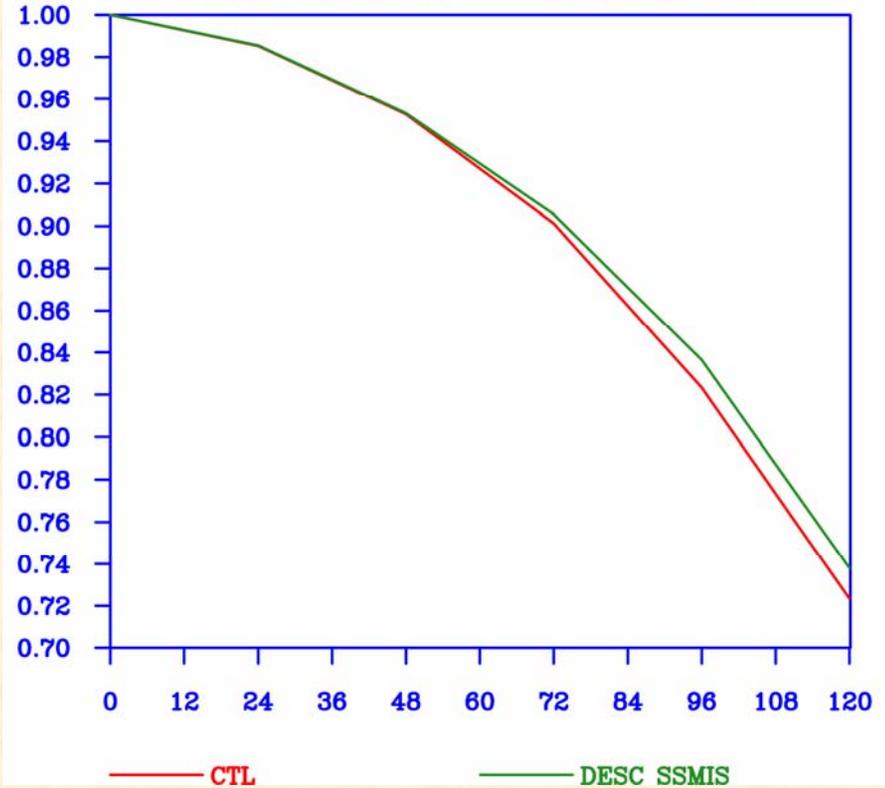
Southern Hemisphere



NOGAPS DATA ASSIMILATION TEST
500 MB SOUTH HEM HEIGHT ANOMALY COR
2005111100 - 2005121200



NOGAPS DATA ASSIMILATION TEST
1000 MB SOUTH HEM HEIGHT ANOMALY COR
2005111100 - 2005121200



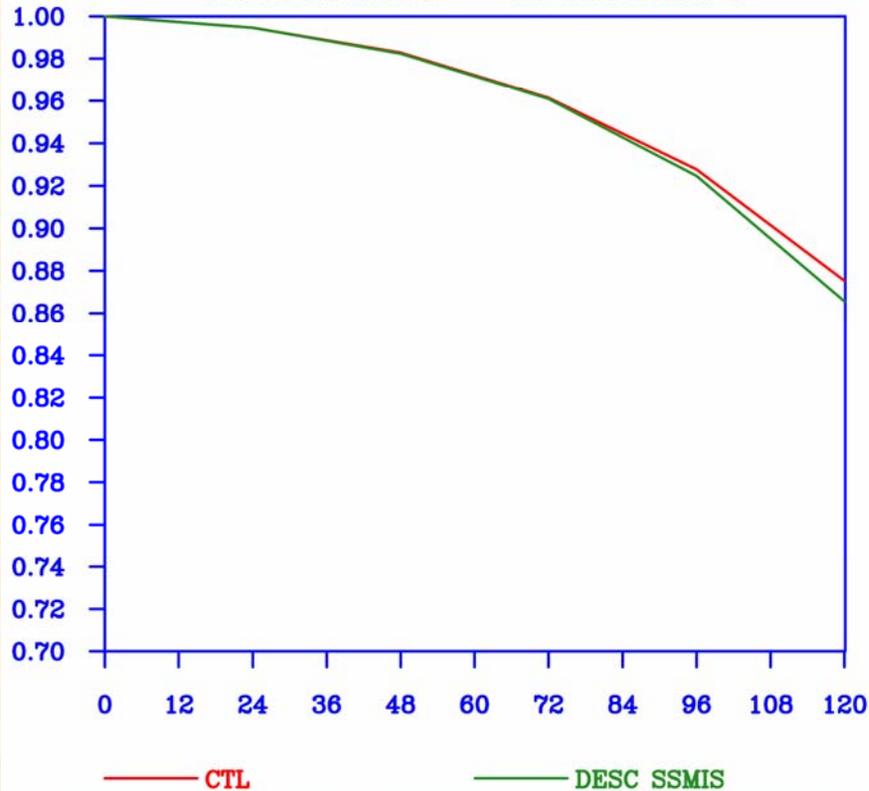
OPS vs. Ops + Descending SSMIS



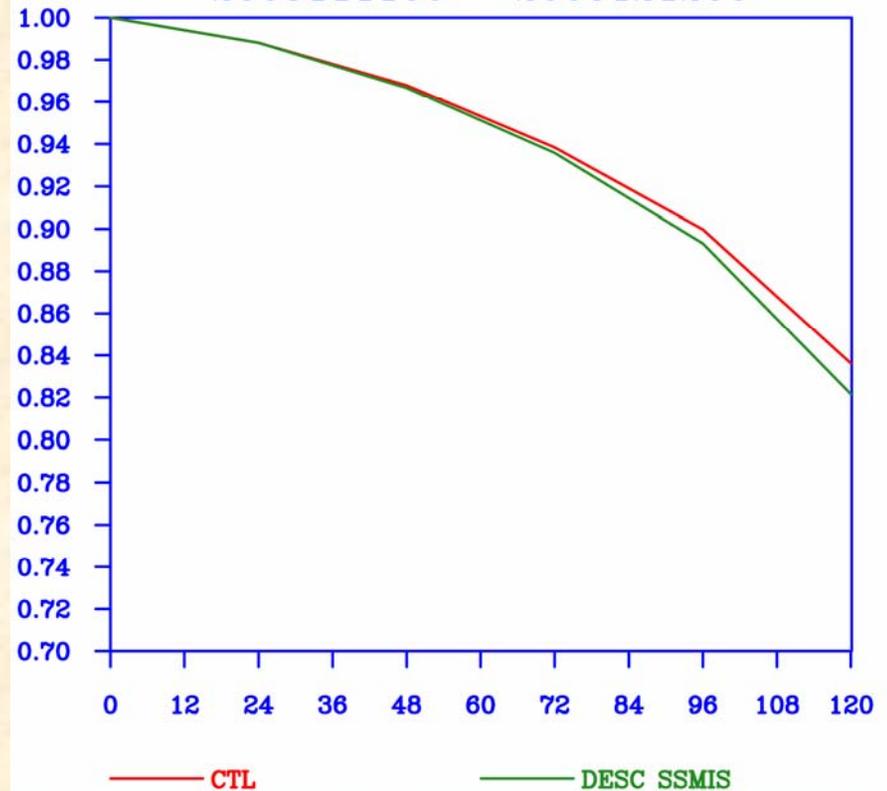
Northern Hemisphere



NOGAPS DATA ASSIMILATION TEST
500 MB NORTH HEM HEIGHT ANOMALY COR
2005111100 - 2005121200



NOGAPS DATA ASSIMILATION TEST
1000 MB NORTH HEM HEIGHT ANOMALY COR
2005111100 - 2005121200



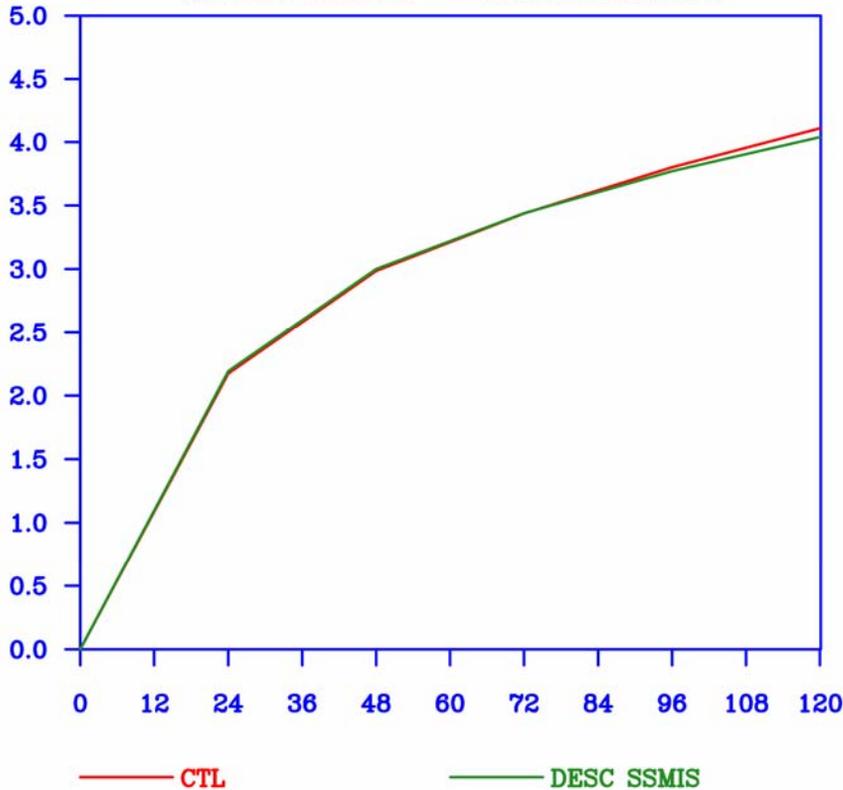
OPS vs. Ops + Descending SSMIS



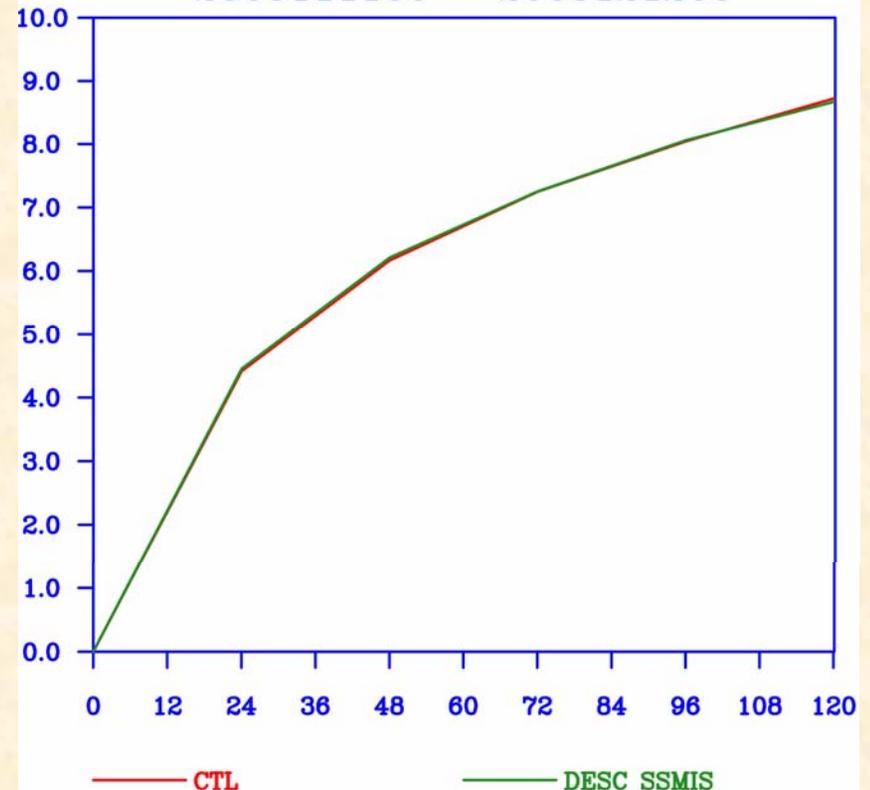
Tropics



NOGAPS DATA ASSIMILATION TEST
850 MB TROPICS VEC RMS WIND ERROR
2005111100 - 2005121200



NOGAPS DATA ASSIMILATION TEST
250 MB TROPICS VEC RMS WIND ERROR
2005111100 - 2005121200



OPS vs. Ops + Descending SSMIS



NRL Test 2 Results



- Test 2: **No NOAA-15 vs. No NOAA-15 + Descending SSMIS**
 - Our test results to date are completely neutral in both hemispheres for 500 hPa and 1000 hPa heights, and for tropical 850 hPa and 250 hPa winds



Future SSMIS Sensors



- The next satellite to carry the SSMIS instrument (DMSP-F17) will address the main calibration issues of the first SSMIS:
- Hardware modifications
 - Fence to mitigate warm-load intrusions
 - Reflector coating has not been sitting for years
 - Reflector temperature sensor in center, which ought to provide a better emissivity correction should it be needed
- Experience with integrating Cal/Val and data assimilation experiments to detect and correct anomalies
- Terminator orbit



Summary and Conclusions



- SSMIS has neutral to slightly positive impact on top of current sensors in Met Office tests; mixed results in NRL tests
- If an AMSU-A instrument fails, only SSMIS can replace it in the near future
- SSMIS can partially compensate for a missing AMSU-A instrument
- There is benefit in assimilating SSMIS data, despite known problems that we have not yet fully corrected
- We expect that SSMIS performance will improve as calibration anomaly mitigation strategies develop, etc.
- Future SSMIS instruments will be improved
- Data assimilation experiments have shown their worth as part of the Cal/Val process