An Effort toward Assimilation of F16 SSMIS UPP Data in NCEP Global Forecast System (GFS)

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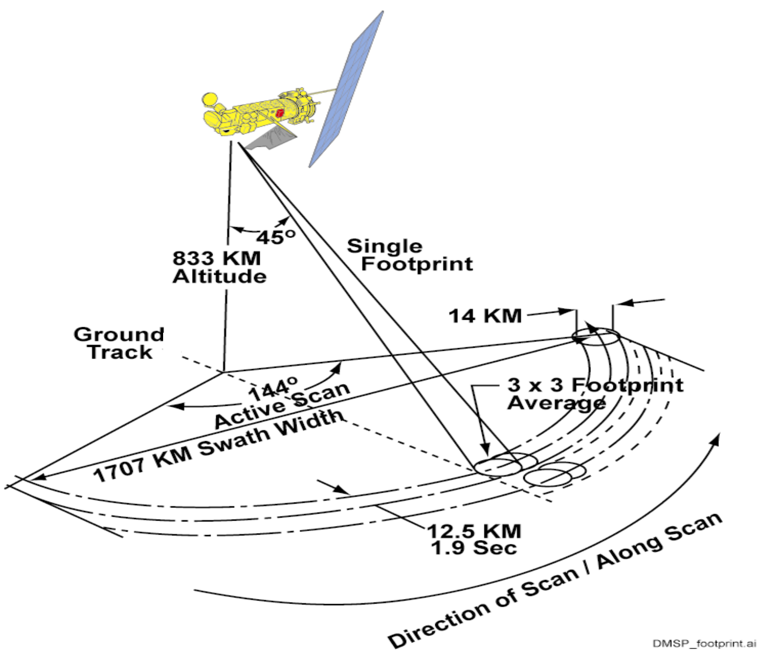
F16 SSMIS Key Characteristics

- **24 Channels (19-183 GHz)**
- **Conical Scan Geometry (45°)**
  - **Relatively stable peak altitude of weight function**
  - **Constant FOV along scan**
  - **Scan position dependent bias**
- **Calibration Anomaly: solar intrusion and antenna emission**



(Kunkee et al. 2008)

TABLE 1. Channel characteristics of SSMIS sensor (Poe et al. 2001)

Channel	Center Freq.(GHz)	3-db Width (MHz)	Freq. Stab.(MHz)	Pol.	NEDT (K)	Sampling Interval(km)
1	50.3	380	10	V	0.34	37.5
2	52.8	389	10	V	0.32	37.5
3	53.596	380	10	V	0.33	37.5
4	54.4	383	10	V	0.33	37.5
5	55.5	391	10	V	0.34	37.5
6	57.29	330	10	RCP	0.41	37.5
7	59.4	239	10	RCP	0.40	37.5
8	150	1642(2)	200	H	0.89	12.5
9	183.31+/-6.6	1526(2)	200	H	0.97	12.5
10	183.31+/-3	1019(2)	200	H	0.67	12.5
11	183.31+/-1	513(2)	200	H	0.81	12.5
12	19.35	355	75	H	0.33	25
13	19.35	357	75	V	0.31	25
14	22.235	401	75	V	0.43	25
15	37	1616	75	H	0.25	25
16	37	1545	75	V	0.20	25
17	91.655	1418(2)	100	V	0.33	12.5
18	91.655	1411(2)	100	H	0.32	12.5
19	63.283248+/- 0.285271	1.35(2)	0.08	RCP	2.7	75
20	60.792668+/- 0.357892	1.35(2)	0.08	RCP	2.7	75
21	60.792668+/- 0.357892+/-0.002	1.3(4)	0.08	RCP	1.9	75
22	60.792668+/- 0.357892+/-0.0055	2.6(4)	0.12	RCP	1.3	75
23	60.792668+/- 0.357892+/-0.016	7.35(4)	0.34	RCP	0.8	75
24	60.792668+/- 0.357892+/-0.050	26.5(4)	0.84	RCP	0.9	37.5
Notes	(1) Sampling refers to along scan direction based on 833km spacecraft altitude. (2) NEDT for instrument temperature 0C and calibration target 260K with integration times of 8.4 msec for Channels 12-16; 12.6 msec for Channels 1-7, 24; and 25.2 msec for Channels 19-23 and 4.2 msec for Channels 8-11, 17-18. (3) Number of sub-bands is indicated by (n) next to individual 3-db width (4) RCP denotes right-hand circular polarization.					

LAS

SSM/I like-CHs

UAS

<u>No.1:</u> Accurate calibration anomaly and scan-dependent bias corrections for F16 SSMIS data since forecast model uses a unbiased data

F16 SSMIS Calibration Anomaly Correction

- **NRL/UK MetOffice SSMIS Unified Pre-Processor (UPP)**
  - **Correct antenna emission for LAS**
  - **Removal of warm load anomaly**
  - **Doppler shift correction for UAS**
  - **Spatial averaging to reduce to the sub-Kelvin levels**

- **NESDIS SSMIS Pre-processor**
  - **Correct antenna emission for LAS**
  - **Removal of warm load anomaly**
  - **UAS bias removal using SABER (Sounding of the Atmosphere using Broadband Emission Radiometry) measurements simulated as truth**
  - **Spatial filter for noise reduction**
  - **Linear mapping of SSMIS imager to its predecessor (SSM/I) using the F15 and F16 Simultaneous Conical Overpass observations**
  - **Inter-sensor calibration for SSMIS imager non-linearity (for climate reprocessing)**

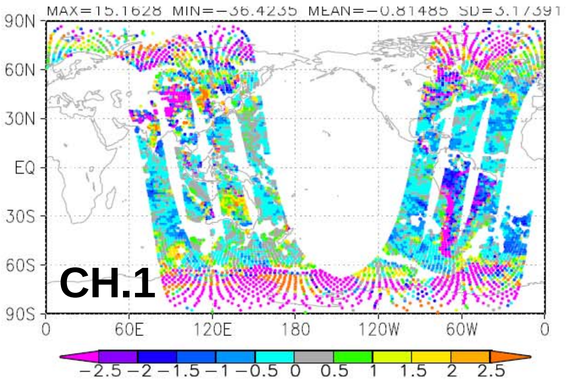
Microwave Sensors Bias Correction in the NCEP GDAS

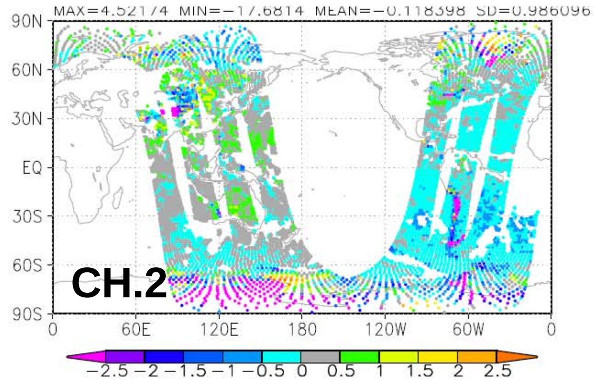
- Angle dependent (Cross-track sensors)
- Scan beam position dependent (Conic scanning sensors)
- Simple non-linear equation to predict bias
  - Control vector augmented by Coefficients (additional analysis variables)
  - Predictors scaled so that same background error variance used for each coefficient
  - Major predictors
    - Scan angle or scan position
    - Lapse rate (Γ)
    - Lapse rate squared (Γ^2)

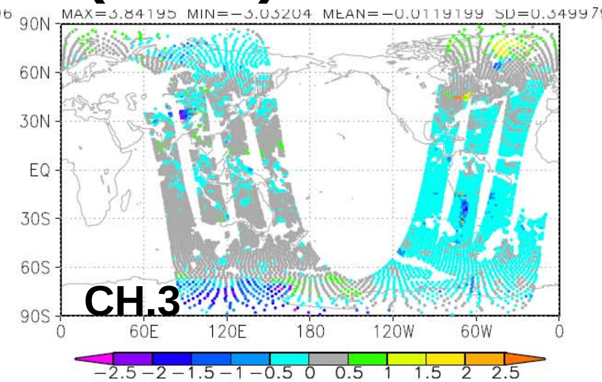
$$\Delta T_B = \Delta T_B^{SCAN}(n) + a_1\Gamma + a_2\Gamma^2 + ..$$

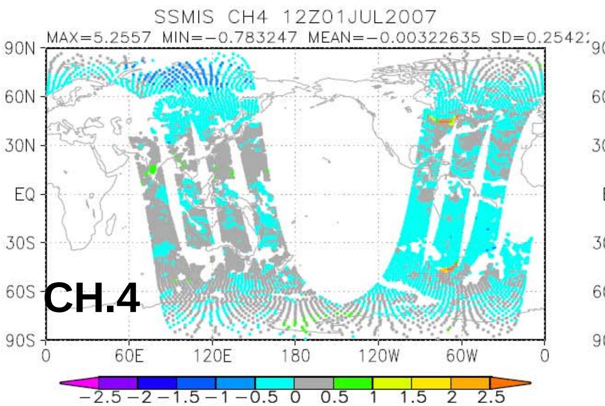
(Derber and Wu)

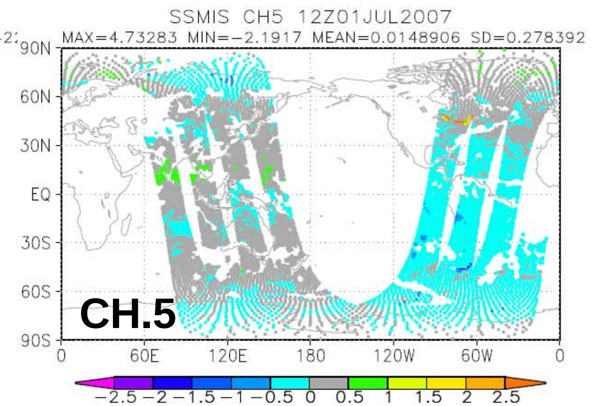
TB (Observation) – TB (Simulation) Differences (DTB) for F16 UPP at LAS Channels (WBC)

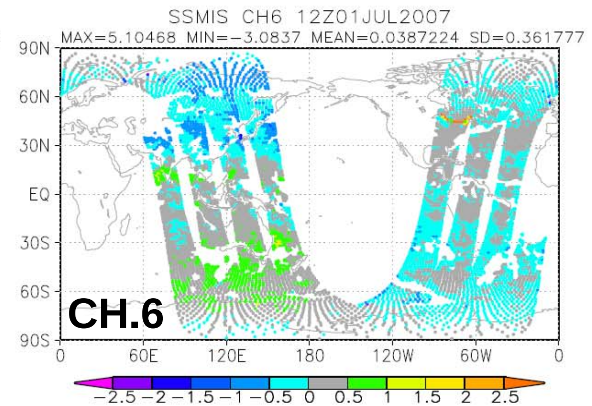


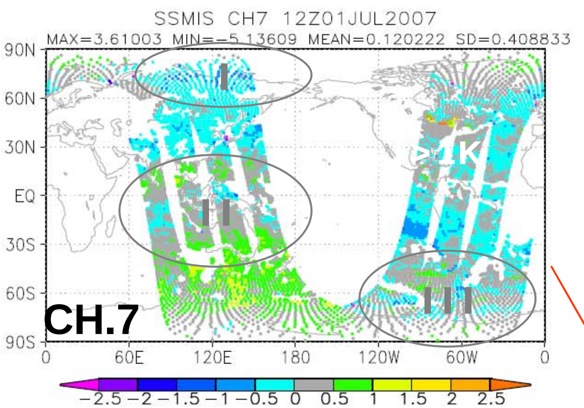








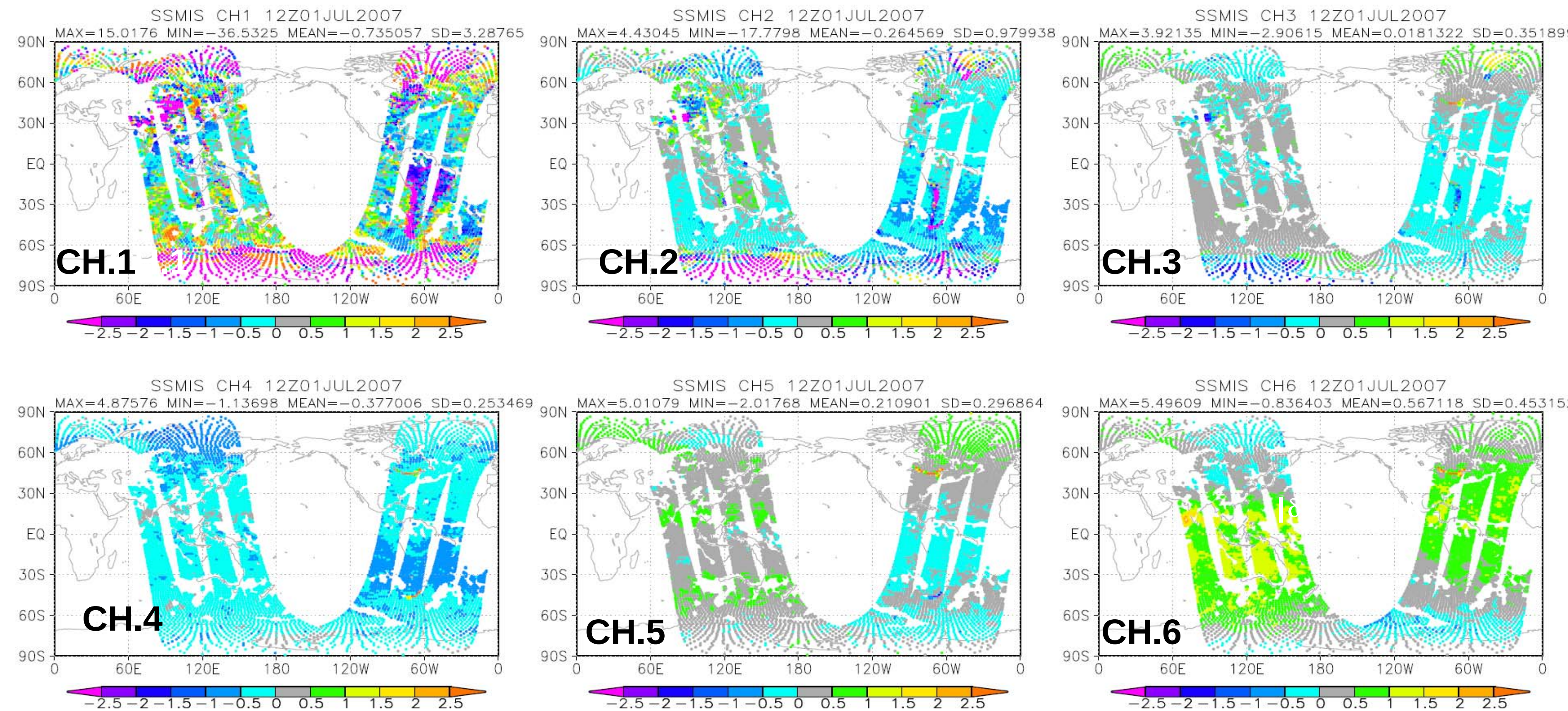


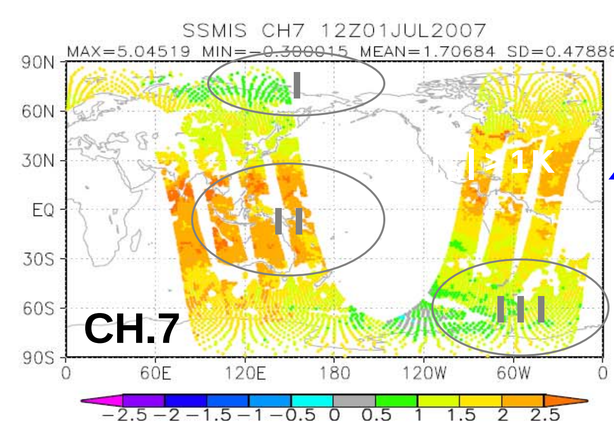


CH.	ΔT_B(wobc)	ΔT_B(wbc)	σ (wobc)	σ (wbc)
1	0.74	0.82	3.29	3.17
2	0.26	0.12	0.98	0.99
3	0.02	0.01	0.35	0.35
4	0.38	0.00	0.25	0.25
5	0.21	0.01	0.30	0.28
6	0.57	0.04	0.45	0.36
7	1.71	0.12	0.48	0.41

Regionally dependent bias after bias correction

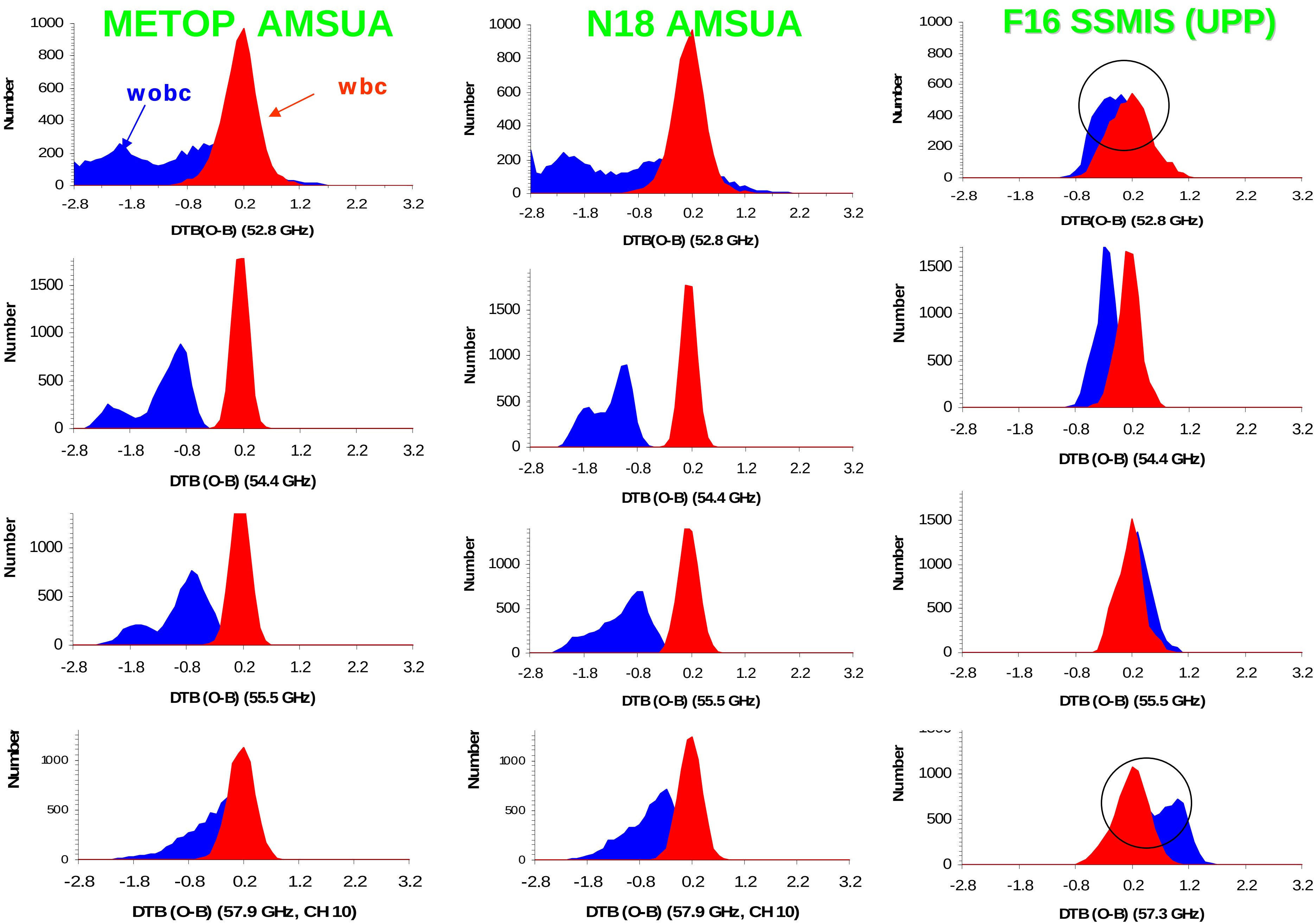
UPP DTB Distributions at LAS Channels (WOBC)





There remain some regional biases after calibration anomaly correction in SSMIS UPP data.

O – B Histograms for QC Passed Data over (Cloud-free) Oceans



No.2: A reliable cloud detection for UPP data quality control

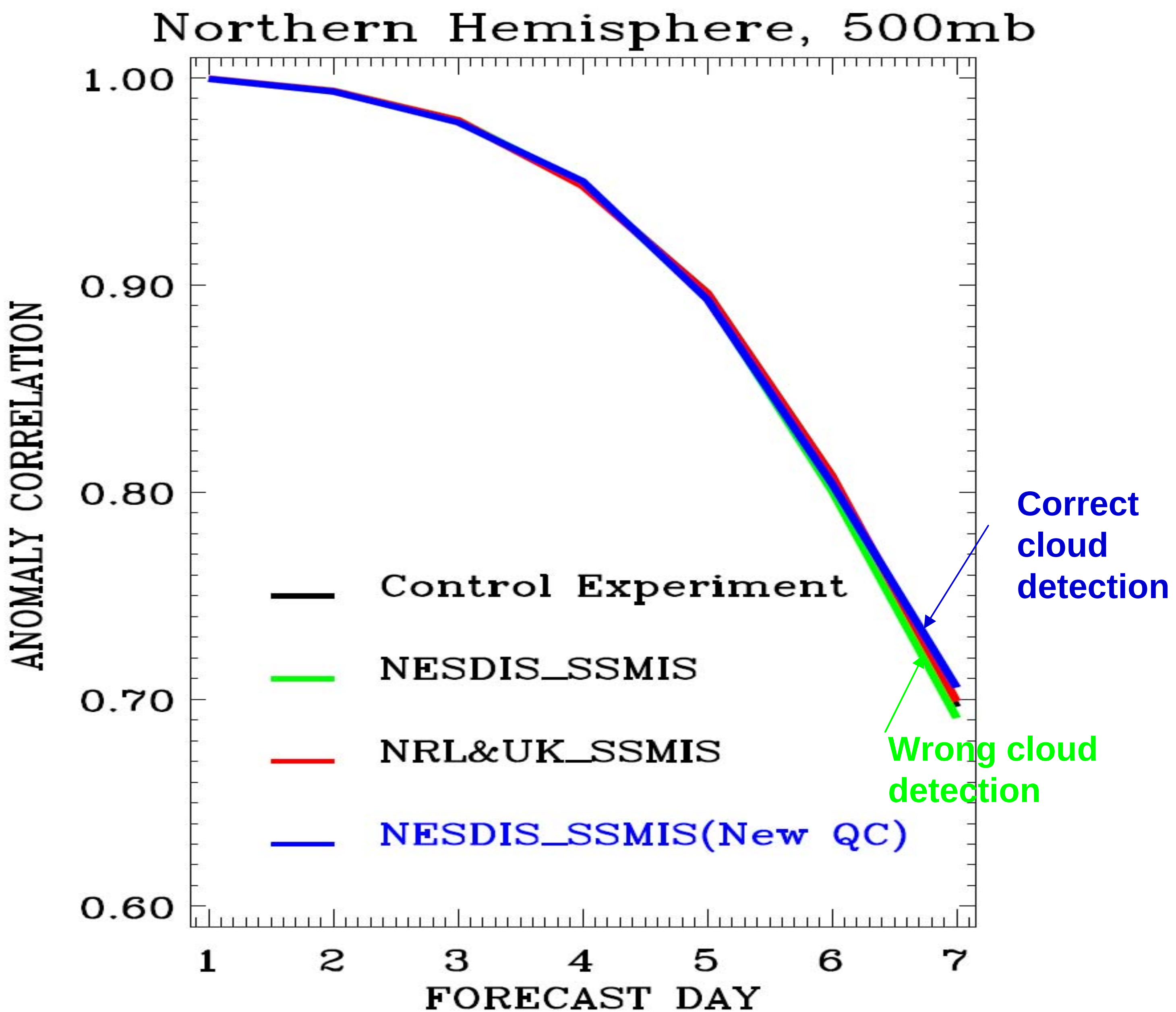
Cloud Detection Algorithms

- Cloud liquid water (CLW) algorithm over oceans: the SSMIS CLW algorithm follows the SSM/I CLW heritage algorithm developed by Weng and Grody (1994), where SSMIS TBs are remapped to SSM/I TB using the remapping coefficients developed by Yan and Weng (2008).

- Cloud detection over land: a newly developed empirical algorithm is used.

- Ice cloud detection: the SSMIS IWP algorithm is developed by Sun and Weng (2008, TGRS) based on the AMSU IWP heritage algorithm developed by Zhao and Weng (2002, JAM).

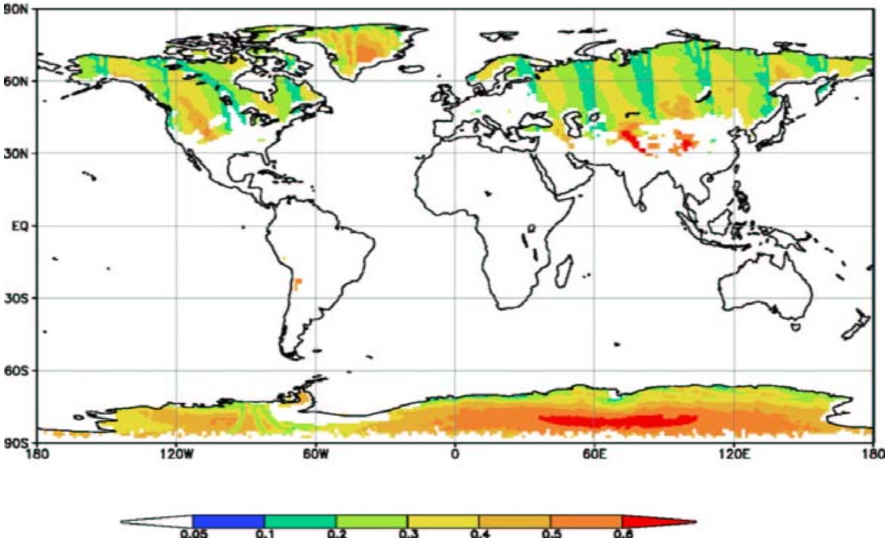
Impacts of Reliable Cloud Detection Quality Control on SSMIS Data Assimilation



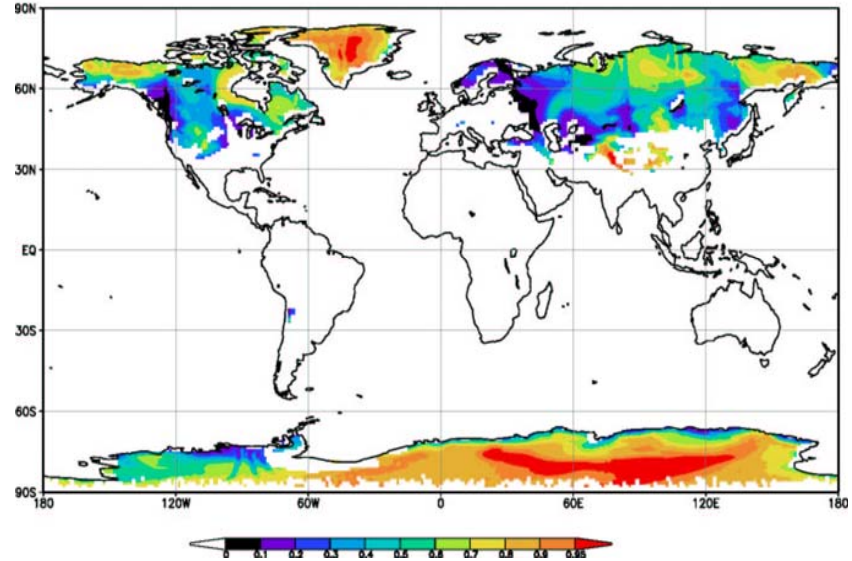
_No. 3:_ Reliable surface emissivity information for accurate SSMIS brightness temperature simulations

Atmospheric Transmittance at Four Sounding Channels

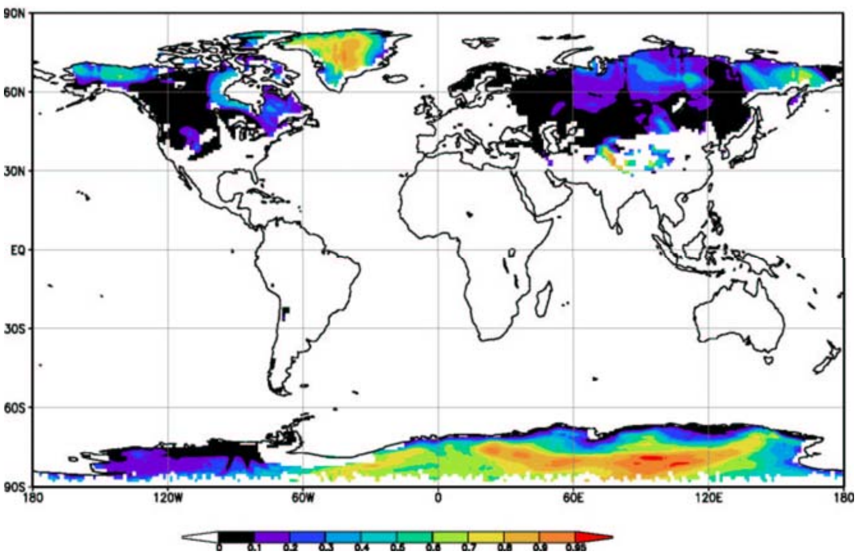
(a) Atmospheric Transmittance at 52.8 GHz



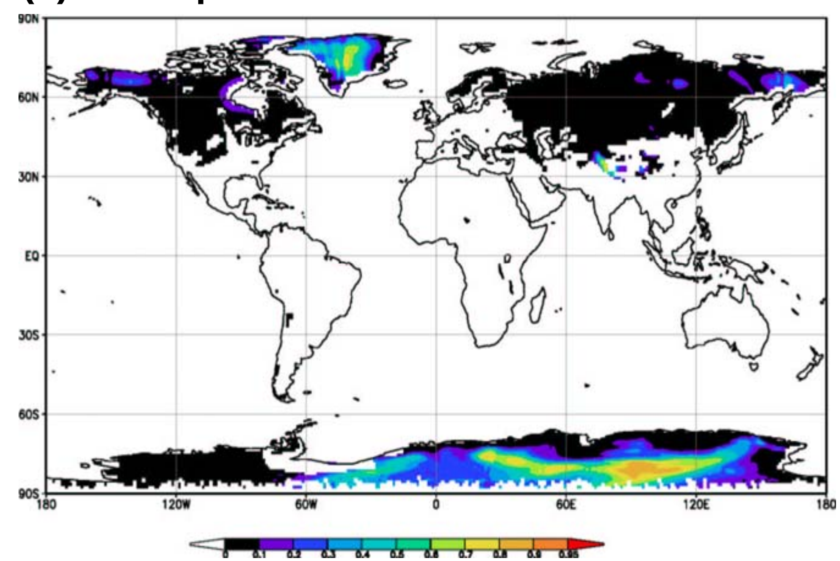
(b) Atmospheric Transmittance at 183±7 GHz



(c) Atmospheric Transmittance at 183±3 GHz



(d) Atmospheric Transmittance at 183±1 GHz



Microwave Surface Emissivity Models in JCSDA Community Radiative Transfer Model

Five Surface Types

Ocean

Sea Ice

Snow

Canopy (bare soil)

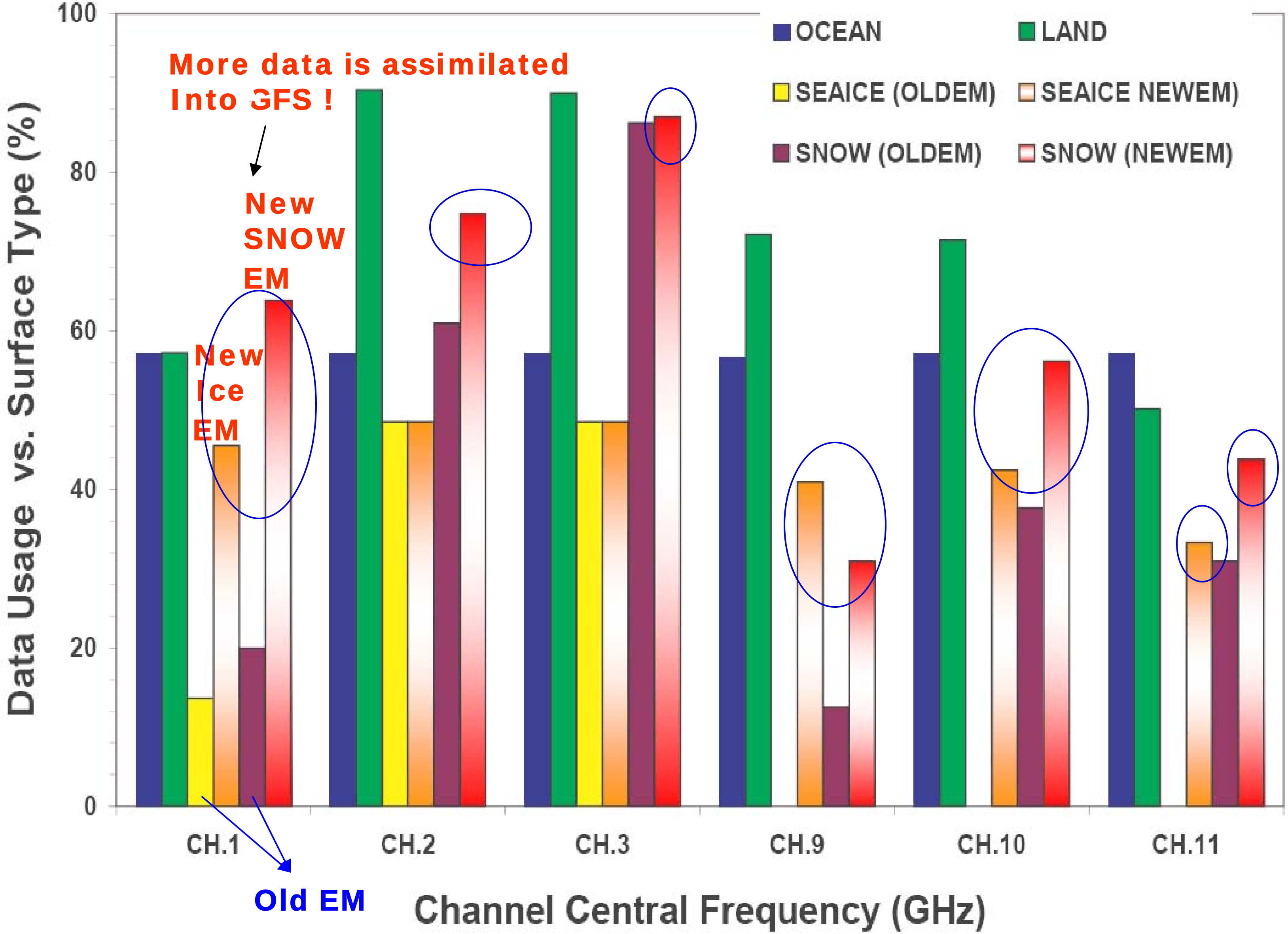
Desert

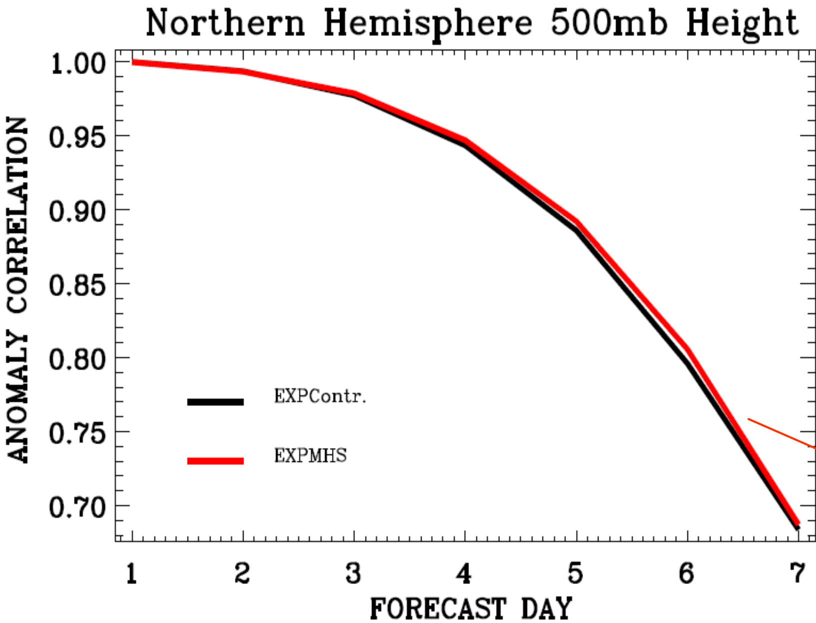
A microwave land emissivity model (LandEM) was developed by F. Weng, B. Yan, N. Grody (JGR, 2001)

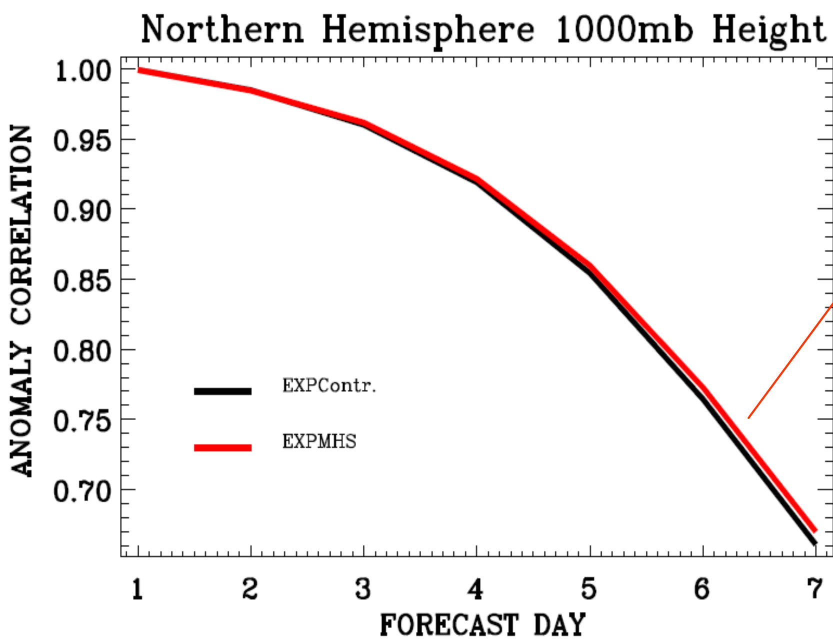
Empirical snow and sea ice emissivity algorithm using microwave satellite window channels of measurements (B. Yan and F. Weng, 2003; 2008)

A fast microwave ocean emissivity model (English, S.J., and T.J. Hewison, 1998)

Impact of Improved Snow and Sea Ice Emissivity at SSMIS Channels on F16 UPP SSMIS Data Usage



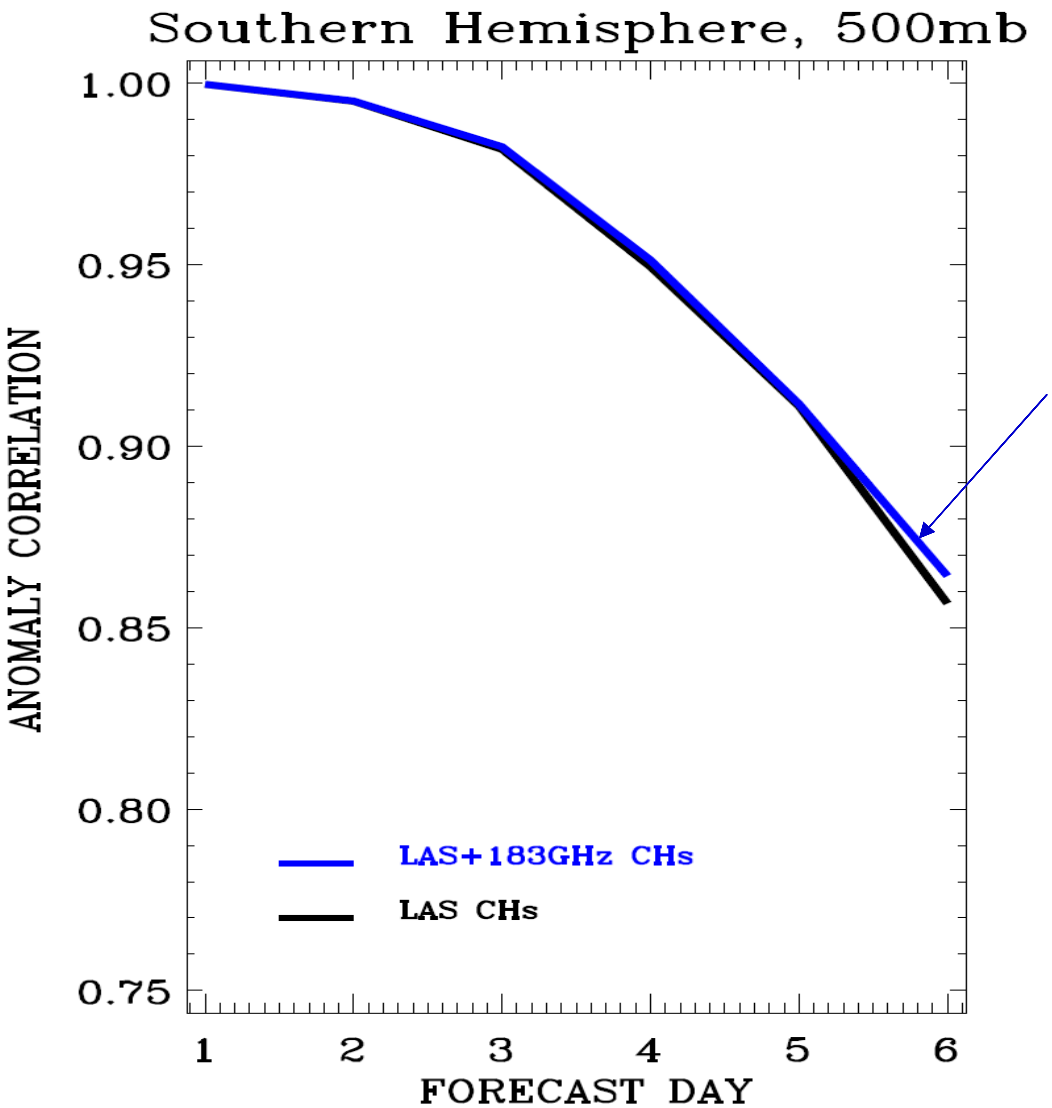




Due to improved snow and sea ice emissivity, a positive impact is seen.

No.4: Assimilation impact of water vapor sounding channels on forecast model

(July 1 ~ July 10, 2007)



A positive impact of SSMIS UPP data at water vapor sounding channels is detected on GFS.

Summary

- Positive impacts of SSMIS UPP data can be obtained through improved cloud detection, surface snow and sea ice emissivity simulations
- A positive impact of SSMIS UPP data is anticipated by adding water vapor channels
- The SSMIS UPP data displays some regional dependent biases at several sounding channels which would reduce their assimilation impact

Future Work

- Continue to investigate assimilation impacts of the SSMIS UPP data at water vapor sounding channels over oceans on GFS analysis fields.

- Investigate assimilation impact of the SSMIS UPP data at LAS and water vapor sounding channels over land, snow and sea ice conditions on GFS.

- Investigate the assimilation impact of SSMIS UPP data for the improved bias correction and quality control schemes on GFS

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