

# Radiance Assimilation Status in WRF-Var

**Zhiquan Liu**

**NCAR/MMM**

**Work supported by AFWA, NASA, NSF, KMA**

**Report at the 2nd CWG meeting**

**April 28 2008**

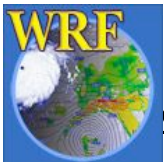


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# Radiance Team

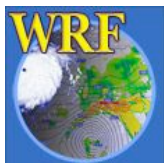
- Zhiquan Liu (Coordination, cloudy radiance)
- Tom Auligné (VarBC, AIRS)
- Hui-Chuan Liu (SSMIS etc.)
- Xin Zhang (software engineering aspects)
- Hui Shao (DATC extended tests)

**NOTE: Some works on radiance in part-time.**



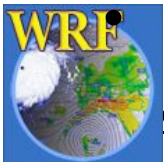
# Outline

- **Components of radiance assimilation**
- **Recent Improvements with CRTM**
- **Radiance impact tests**
- **Cloudy radiance assimilation development using CRTM**
- **4DVAR+Radiance Demonstration**



# Components of radiance assimilation in WRF-Var

- Data Ingestion
  - NCEP radiance BUFR data
    - AMSU-A/B, MHS, HIRS, AIRS
  - SSMIS from AFWA/NRL, UPP produced
- Radiative Transfer Model
  - Both CRTM\_1.1 and RTTOV8\_7
- Bias Correction
  - Scan bias and air-mass bias (Harris and Kelly, 2001)
  - Variational Bias Correction (Derber and Wu, 1998)
- Quality Control: AMSU/MHS, SSMIS, AIRS
- Thinning and Load balancing
- Observation error tuning (Desroziers & Ivanov, 2001)
- Monitoring tool

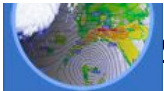
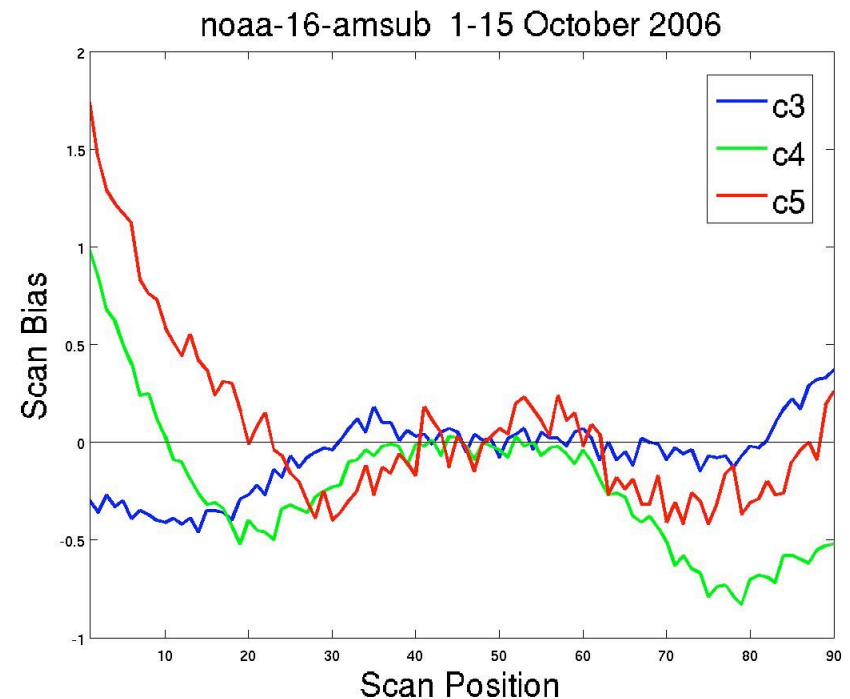
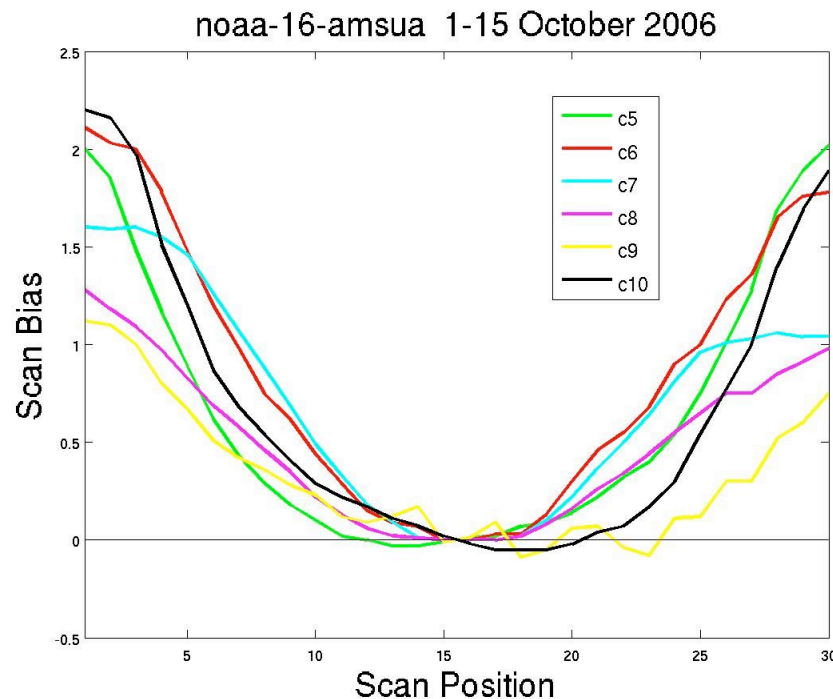


Work for 3DVAR/FGAT/4DVAR

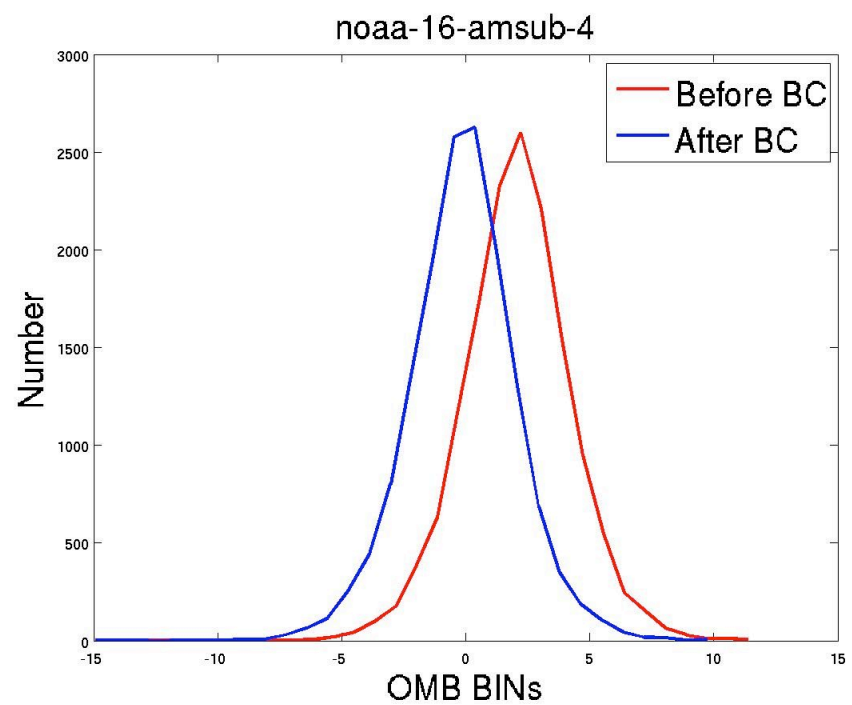
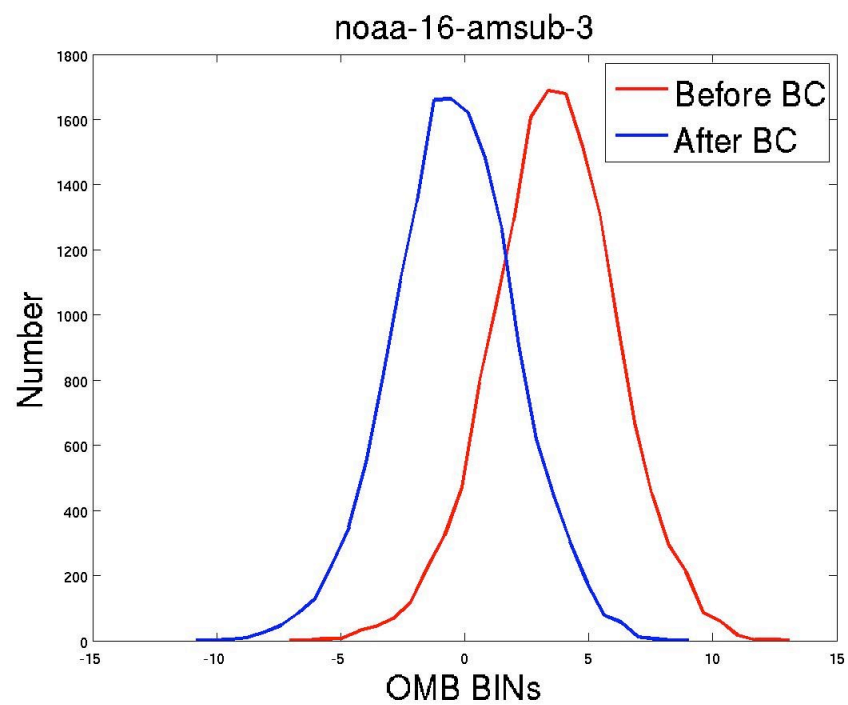
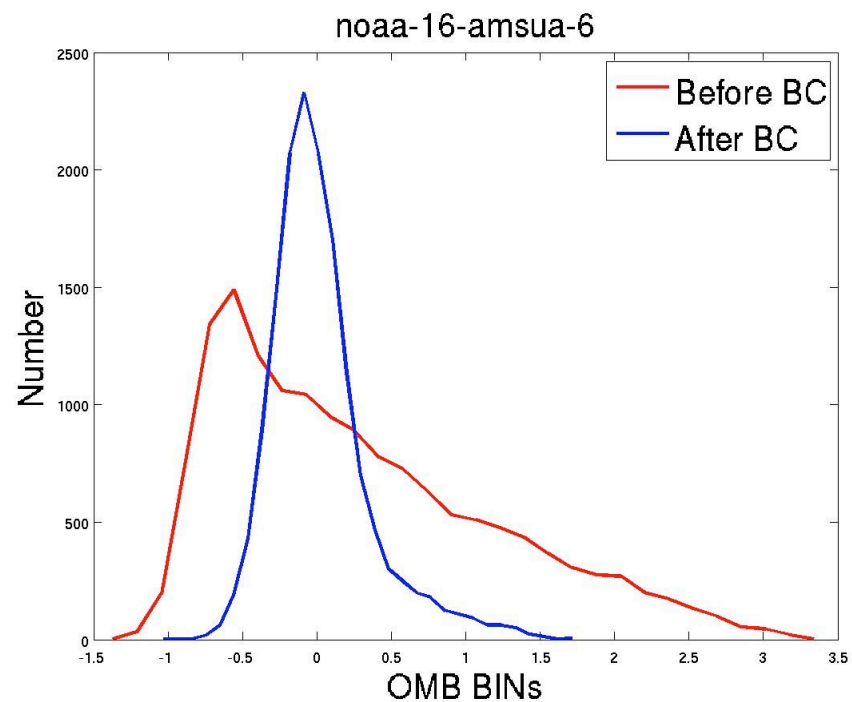
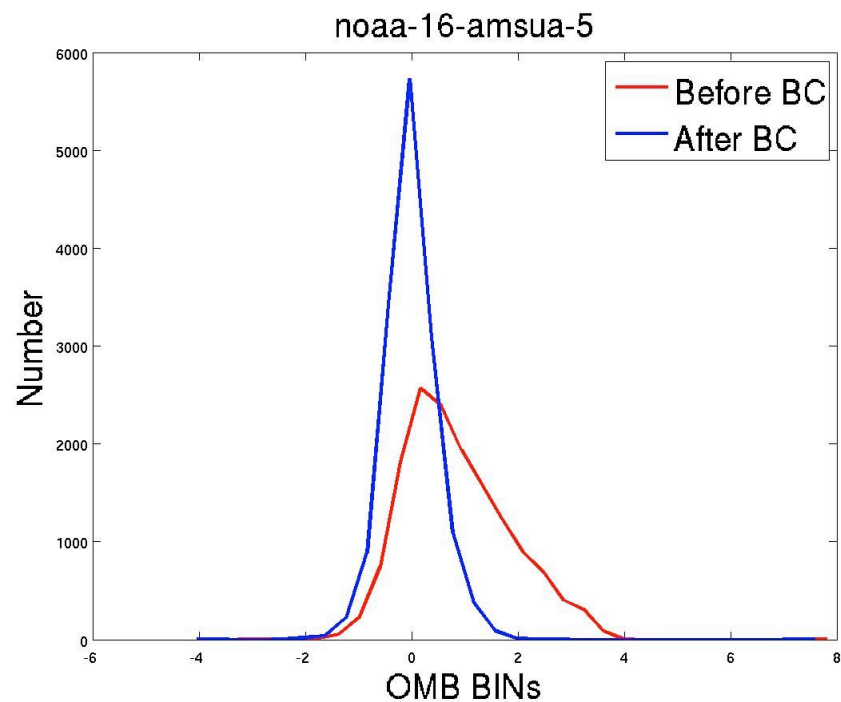
# Scan Bias (H&K, 2001)

- Scan Bias =  $d(\text{limb}) - d(\text{nadir})$ 
  - $d(\cdot)$  is departure (omb or oma)
  - This is relative bias between limb and nadir

Scan bias statistics for SWA domain with 15 days data



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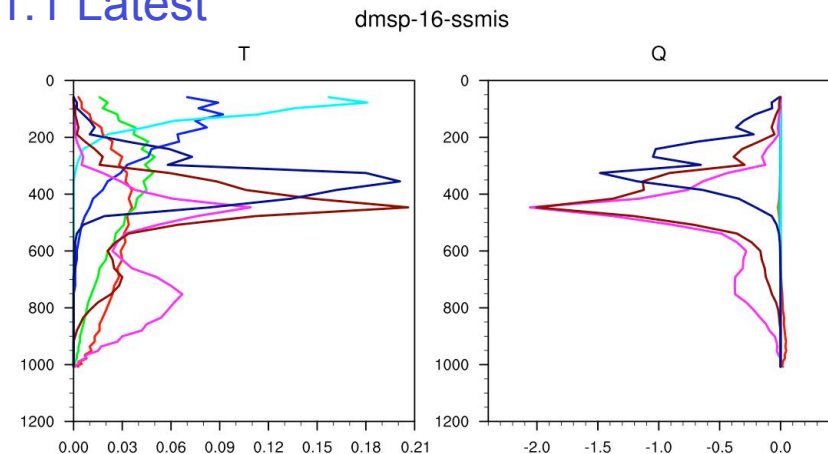
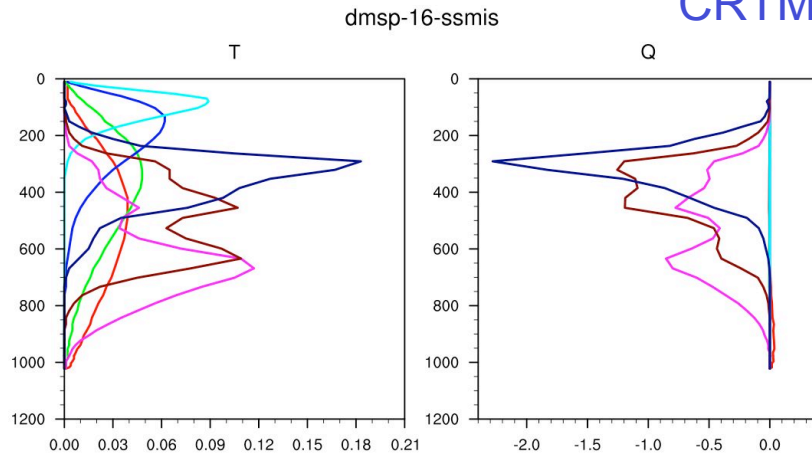


# CRTM Jacobian for SSMIS AMSU-like channels

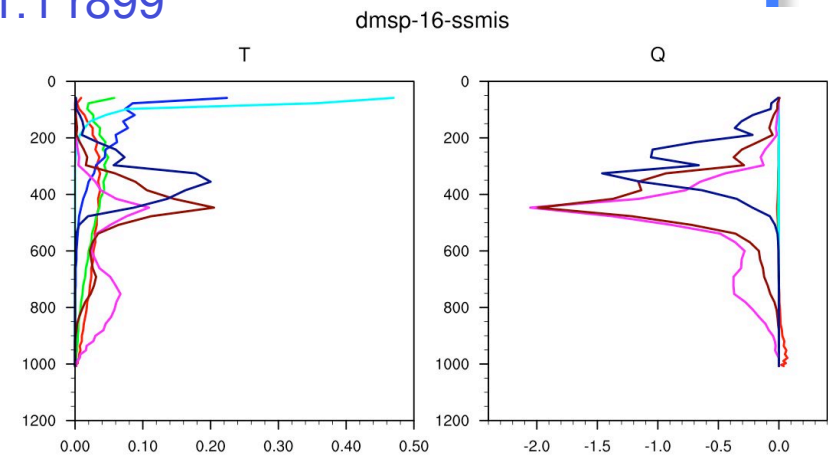
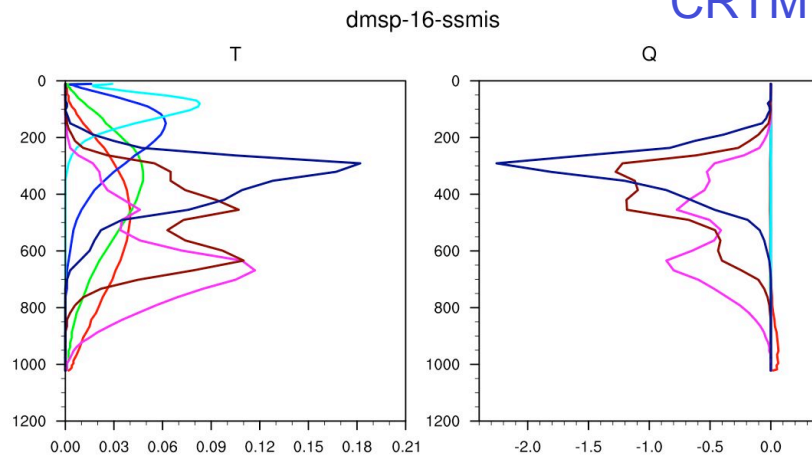
Atlantic domain P<sub>top</sub>=10hPa

East Asia domain P<sub>top</sub>=50hPa

CRTM REL-1.1 Latest



CRTM REL-1.1 r899



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# Recent speed up of CRTM

**Pre-release version (provided by Mark Liu) vs. the latest CRTM release**

**Overall Timing Summary** (from WRF-Var tracing feature)

Routine Name	Calls	Elapsed Time (seconds)				CPU Time (seconds)				Speed up 64 PE
		per PE	Average per PE	%	Minimum	Maximum	Total	%	Minimum	
<a href="#">da_crtm_direct</a>	103.0	0.51	0.2	0.3 on 5	0.8 on 8	16.53	16.6	0.1 on 56	0.4 on 7	32.63
<a href="#">da_crtm_direct</a>	103.0	0.23	0.1	0.1 on 58	0.5 on 15	7.84	8.7	0.0 on 34	0.2 on 15	33.77

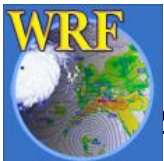
**Forward model 2.2 times faster**

da_crtm_tl	2162.0	15.06	7.3	7.4 on 57	25.9 on 8	474.11	477.2	3.5 on 26	12.5 on 8	31.48
da_crtm_tl	2162.0	8.76	4.6	4.3 on 26	16.7 on 15	277.02	306.0	2.1 on 26	8.4 on 15	31.61

**Tangent Linear model 1.7 times faster**

da_crtm_ad	2265.0	13.39	6.5	8.2 on 26	22.8 on 8	413.68	416.3	3.7 on 26	10.9 on 8	30.90
da_crtm_ad	2265.0	8.01	4.2	4.7 on 26	13.5 on 15	252.30	278.7	2.3 on 57	6.7 on 15	31.49

**Adjoint model 1.67 times faster**





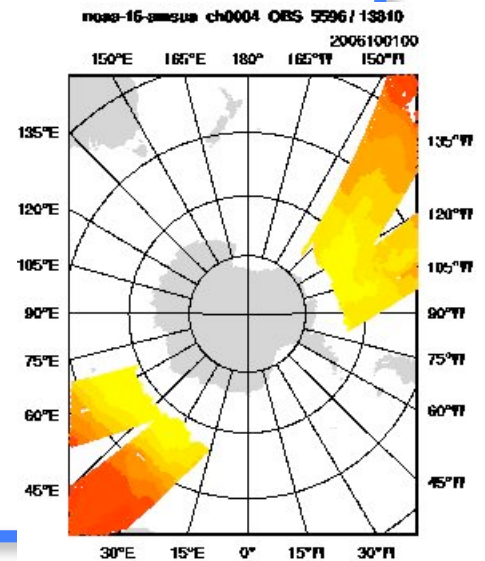
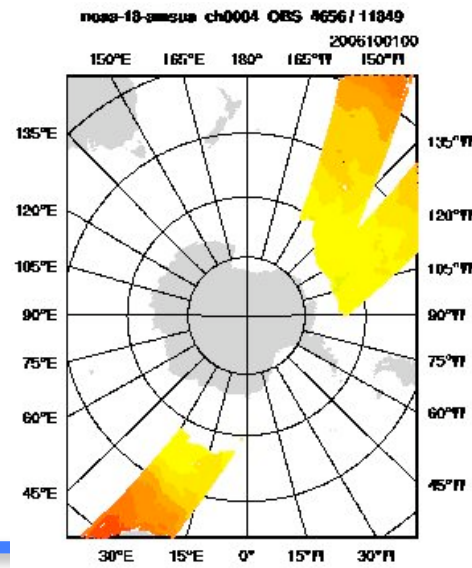
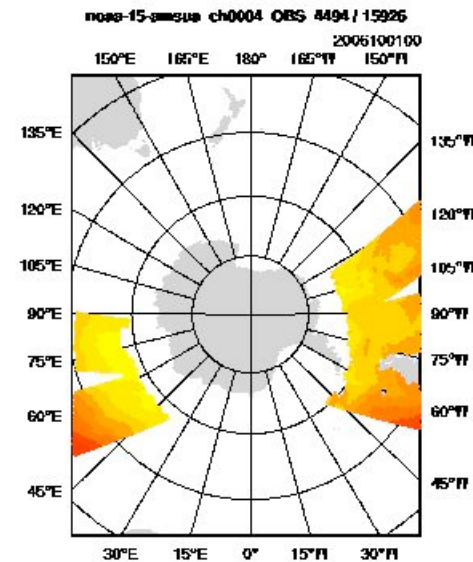
# DATC extended tests

- NCAR/DATC: Data Assimilation Testbed Center
  - Parallel with NCAR/DTC (Developmental Testbed Center), focus on tests for model part
- DATC Testbeds for radiance impact
  - East Asia
  - Atlantic
  - Antarctic



# DATC: Antarctic Testbed

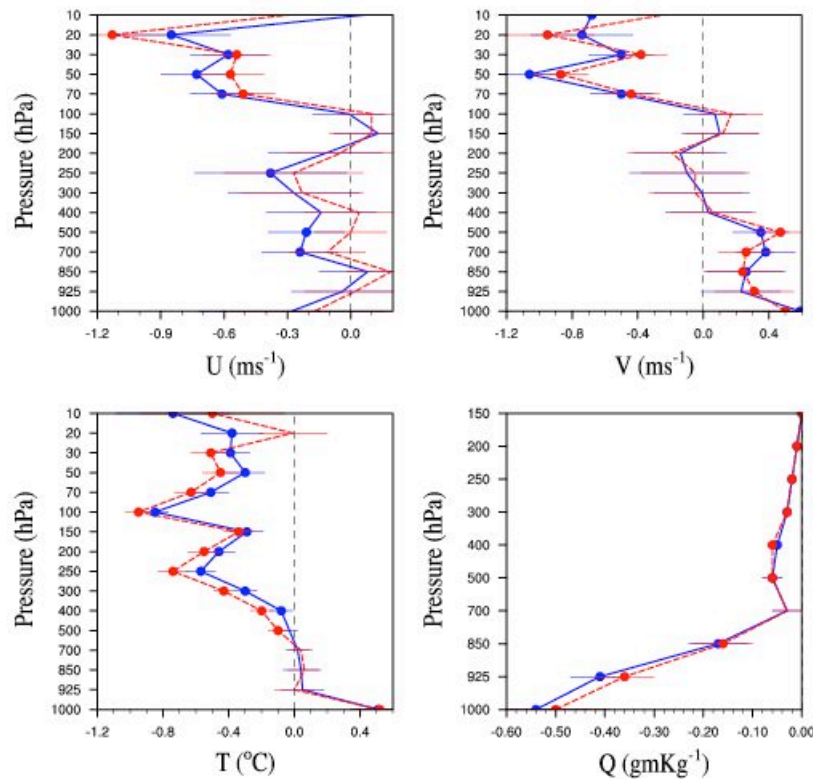
- 57L, 60km
- model top: 10mb
- Full cycling exp. for 14 days
  - 1 ~ 14 October 2006
- GTS: assimilate NCAR conventional obs
- GTS+AMSU-A (NCEP BUFR rad.)
  - NOAA-15/16/18, AMSU-A, ch. 4~9
  - Radiance used only over water
  - +-2h time window
  - Bias Correction (H&K, 2001)



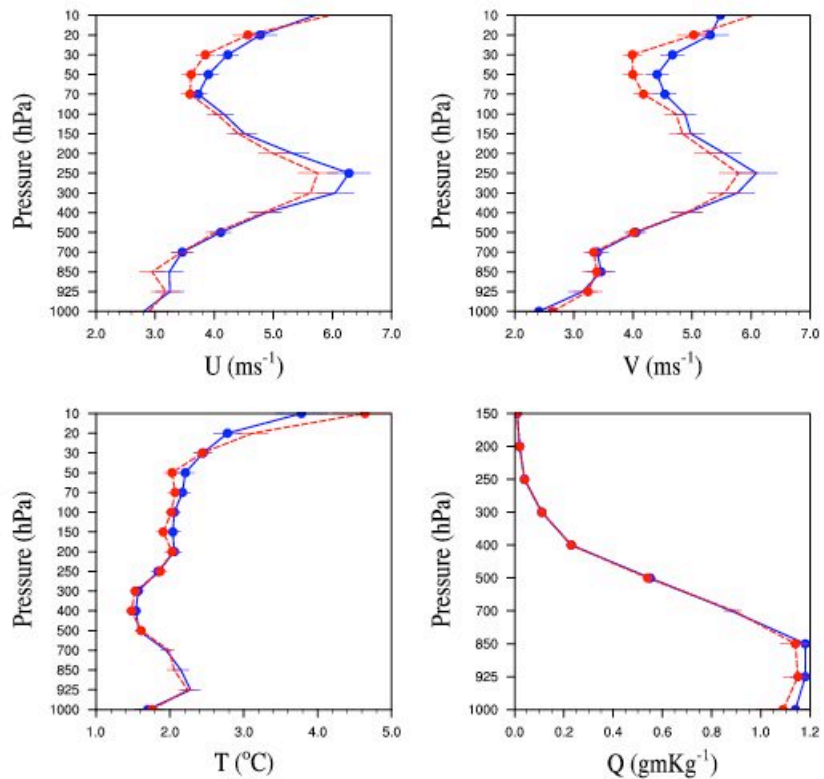
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# 36h forecast vs. Sound

Bias Profiles 02 - 14 October 2006 (12 hour interval)

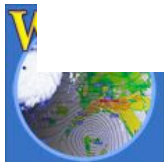


RMSE Profiles 02 - 14 October 2006 (12 hour interval)



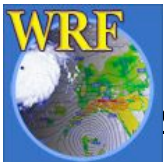
--- GTS+AMSUA  
— GTS

--- GTS+AMSUA  
— GTS



# Cloudy radiance Assimilation

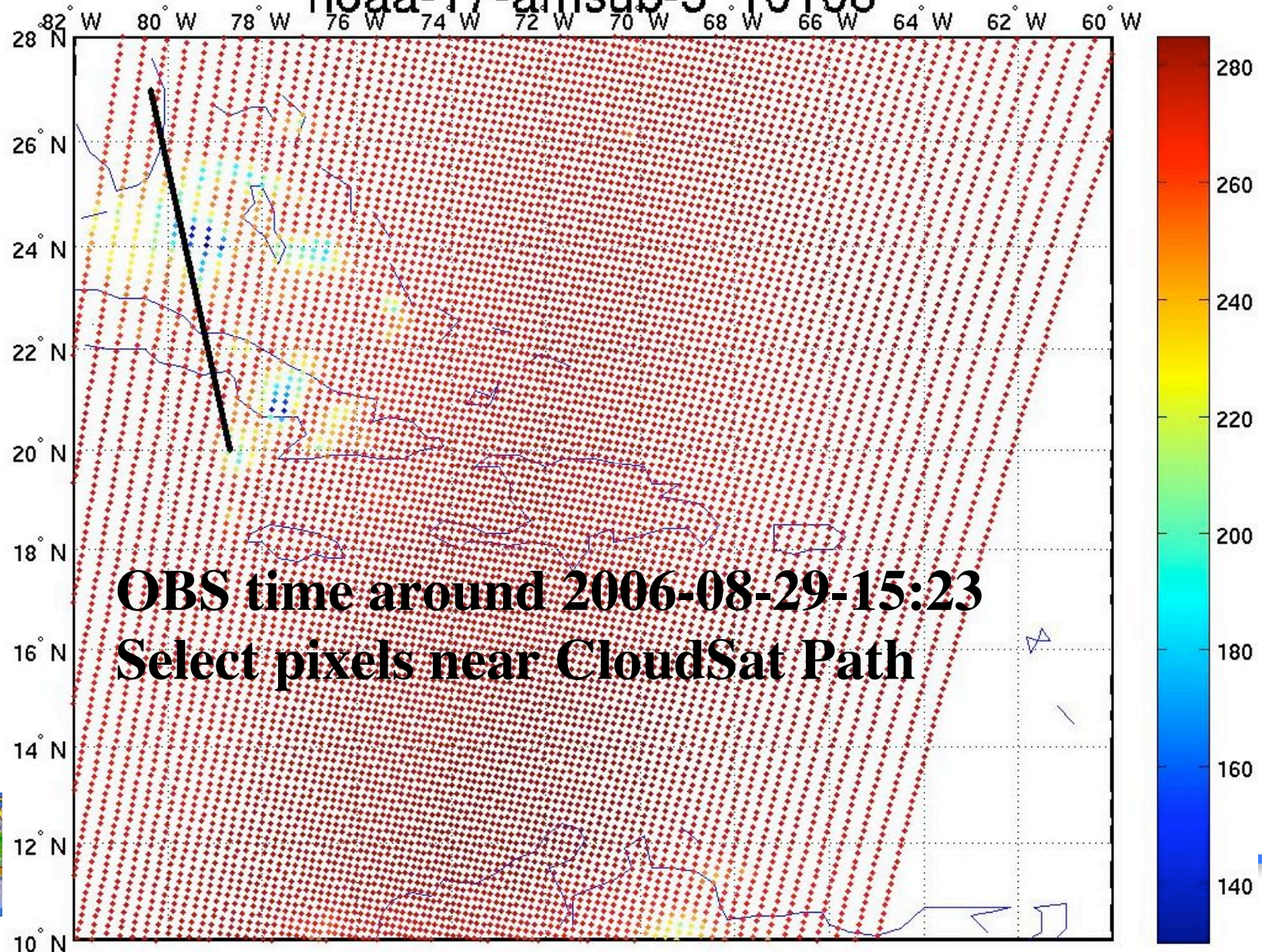
- CRTM cloudy radiance Forward/TL/AD calculation interface implemented
  - Input: hydrometeors profiles and particle radius
- Particle size is diagnosed from cloud water content (Bauer, 2001)
- No hydrometeor control variables available in WRF-3DVAR, instead Total Water ( $Q_t$ ) as control variable, and a warm-rain process' TL/AD is used to partition  $Q_t$  into cloud water and rain (Xiao et al., 2007) in 3DVAR
  - Warm-rain process limits the application
- Initial test with WSM3 microphysics scheme for hydrometeors forecast with a 4km resolution
  - Include cloud water/ice, rain/snow, no mixture phase





# AMSU-B cloudy radiance calculation case

noaa-17-amsub-5 10108



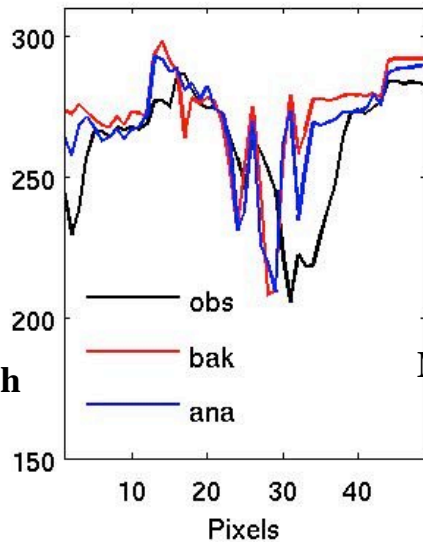


# NOAA-17-AMSUB Tb along CloudSat path

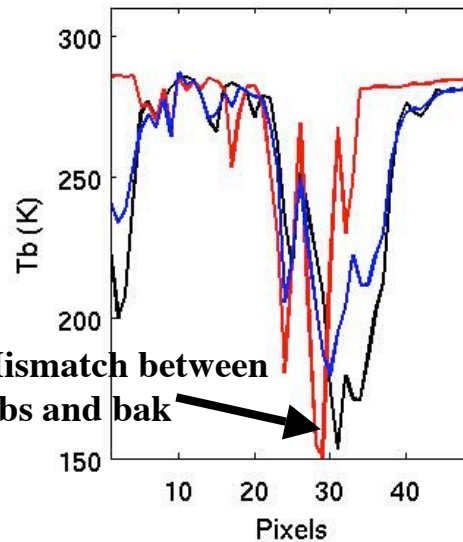
**NO ANY QC**

**CRTM forward  
Calculation looks  
quite good for  
Channels 1 and 2  
Regardless of  
Location mismatch**

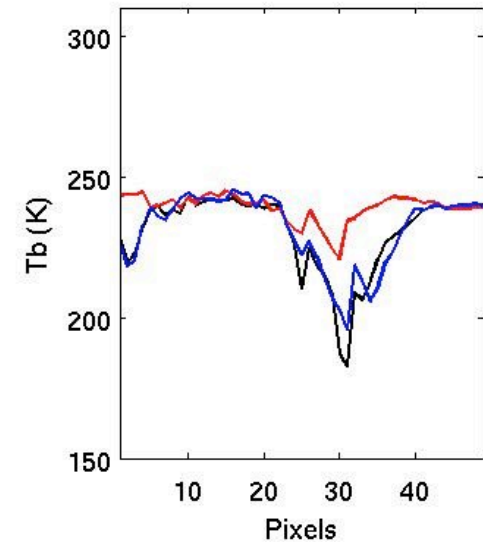
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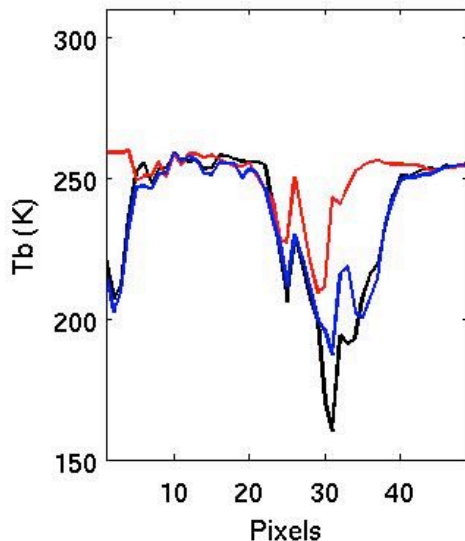
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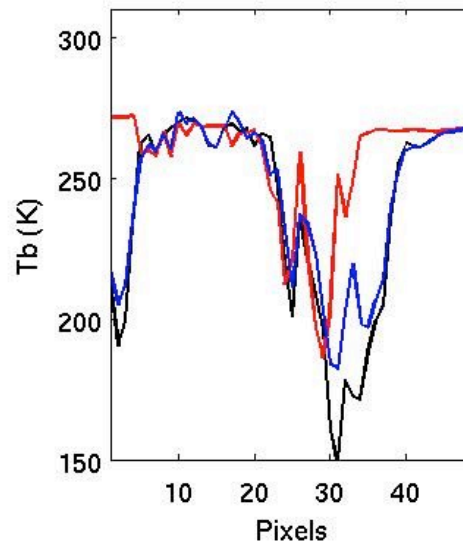
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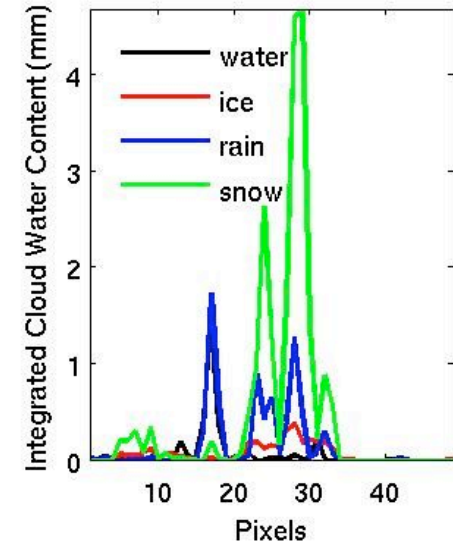
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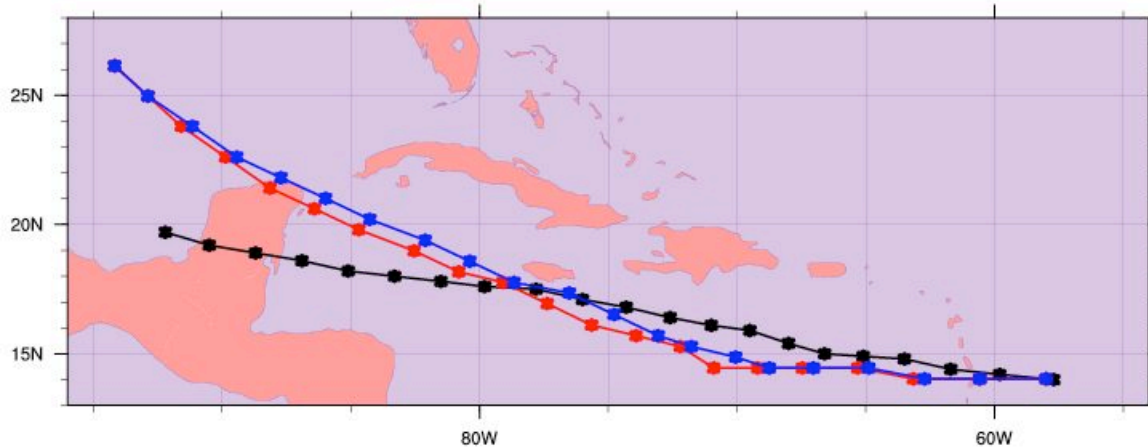
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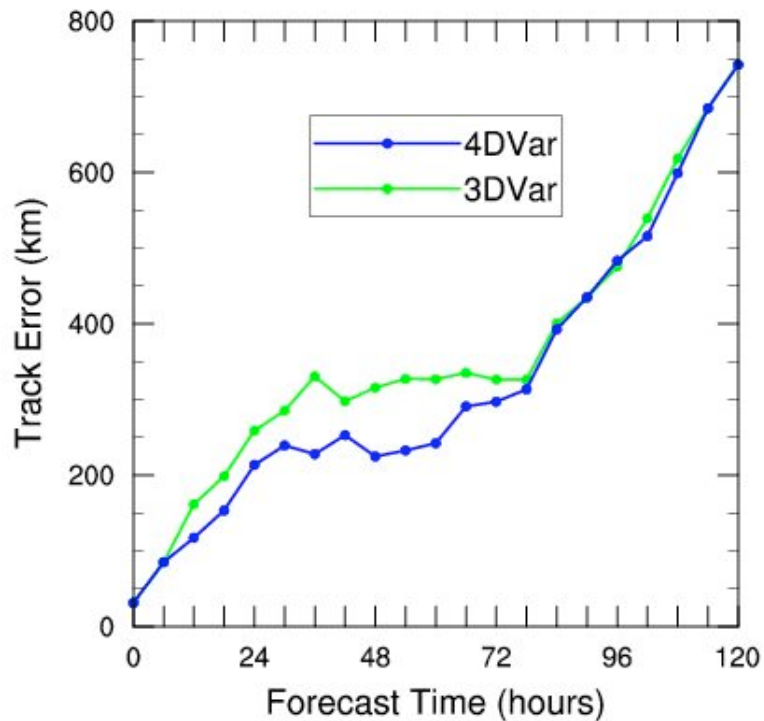
## Total cloud water content



# 4DVAR vs. 3DVAR



Hurricane Dean 07081700



**45km resolution  
(4DVAR is still very slow)**

**model top = 10mb**

**Only assimilate radiance data  
(AMSU/MHS)**

# Future plans

- Add more instruments
  - IASI, GOES platforms
- Tune the system for various testbeds
- Further developments for cloudy radiance assimilation and 4DVAR+radiance
- Explore ensemble-based radiance assimilation

