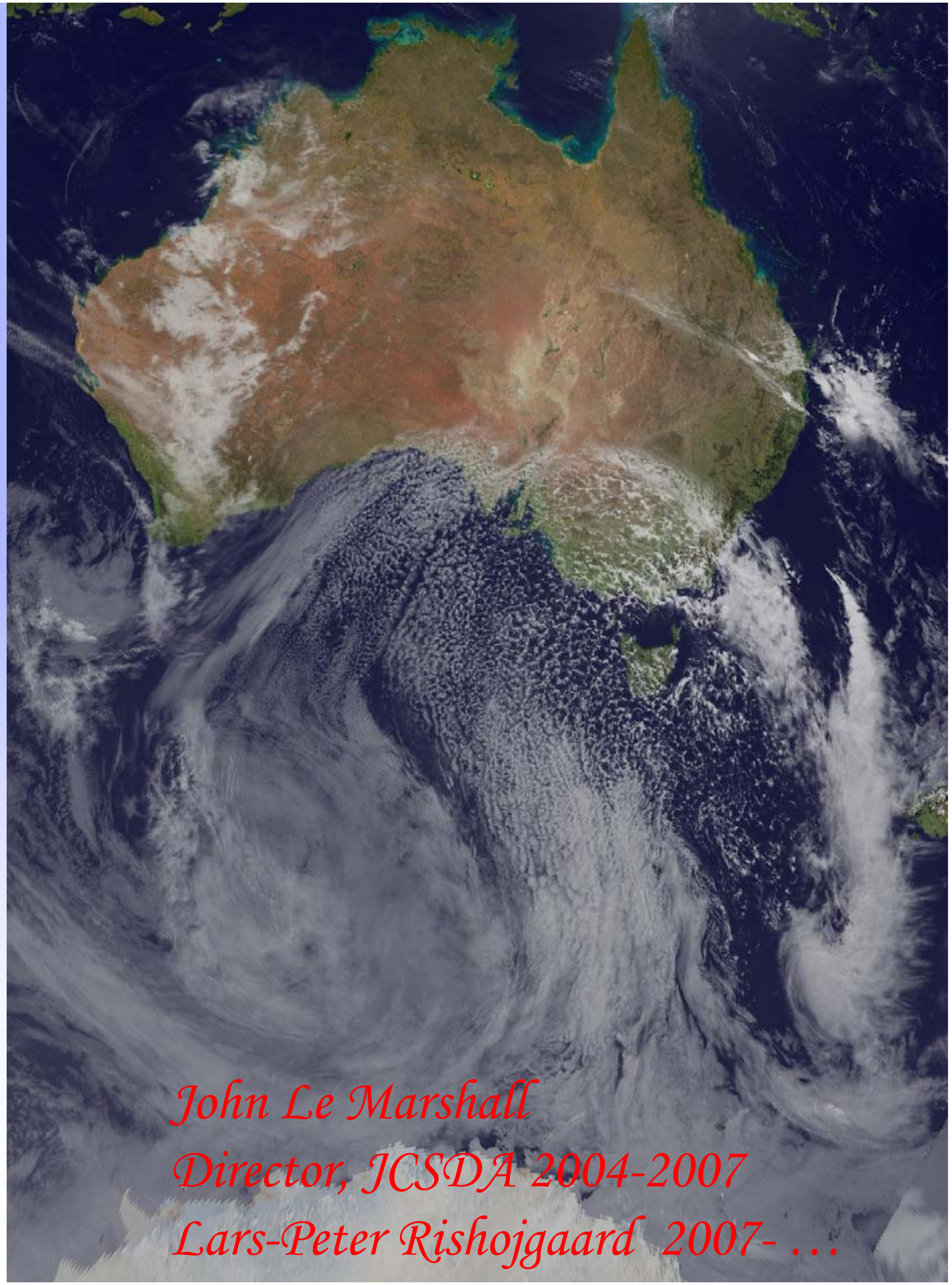
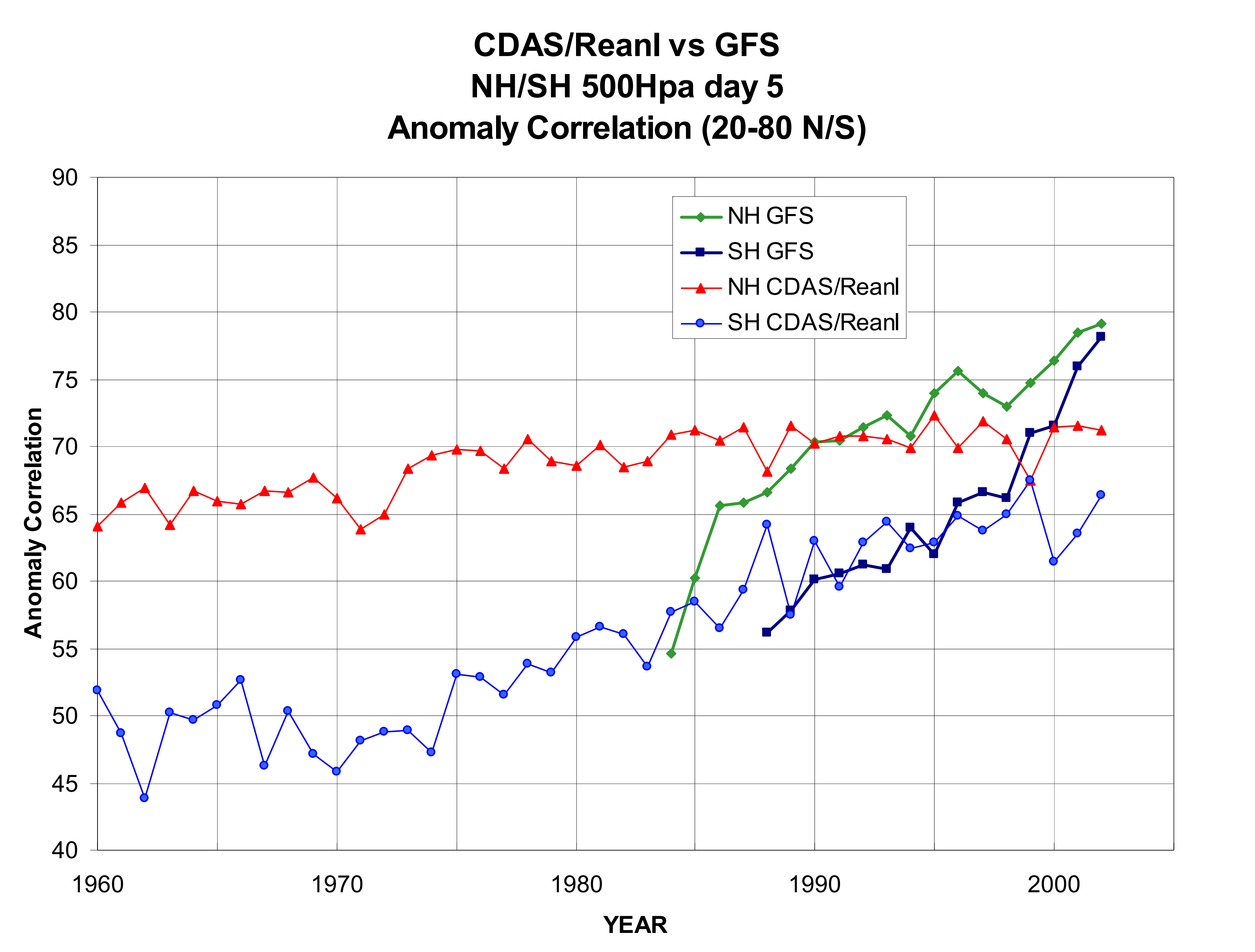
The Impact of Satellite Data in the Joint Center for Satellite Data Assimilation (JCSDA)



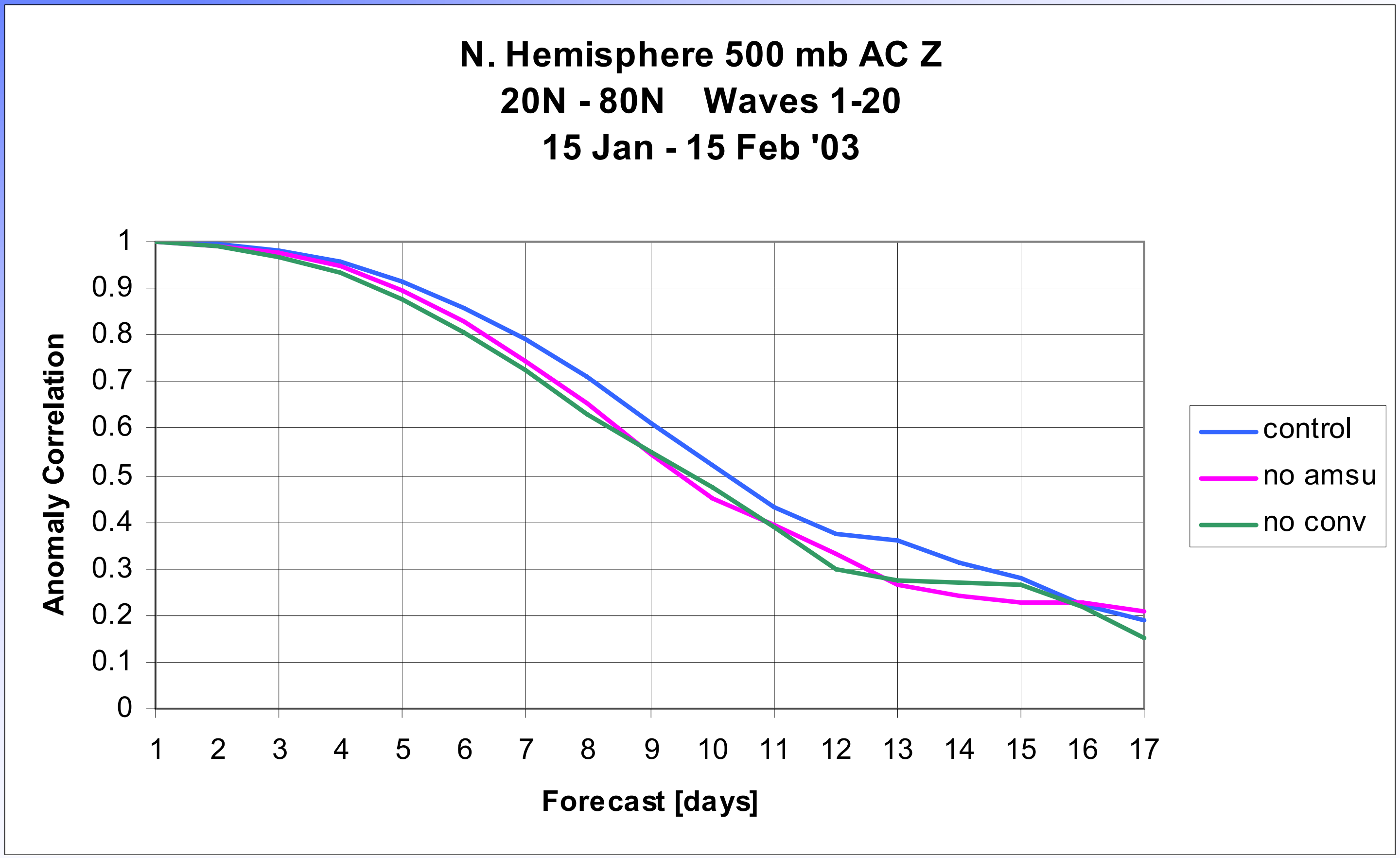
John Le Marshall
Director, JCSDA 2004-2007
Lars-Peter Rishojgaard 2007- …

Overview

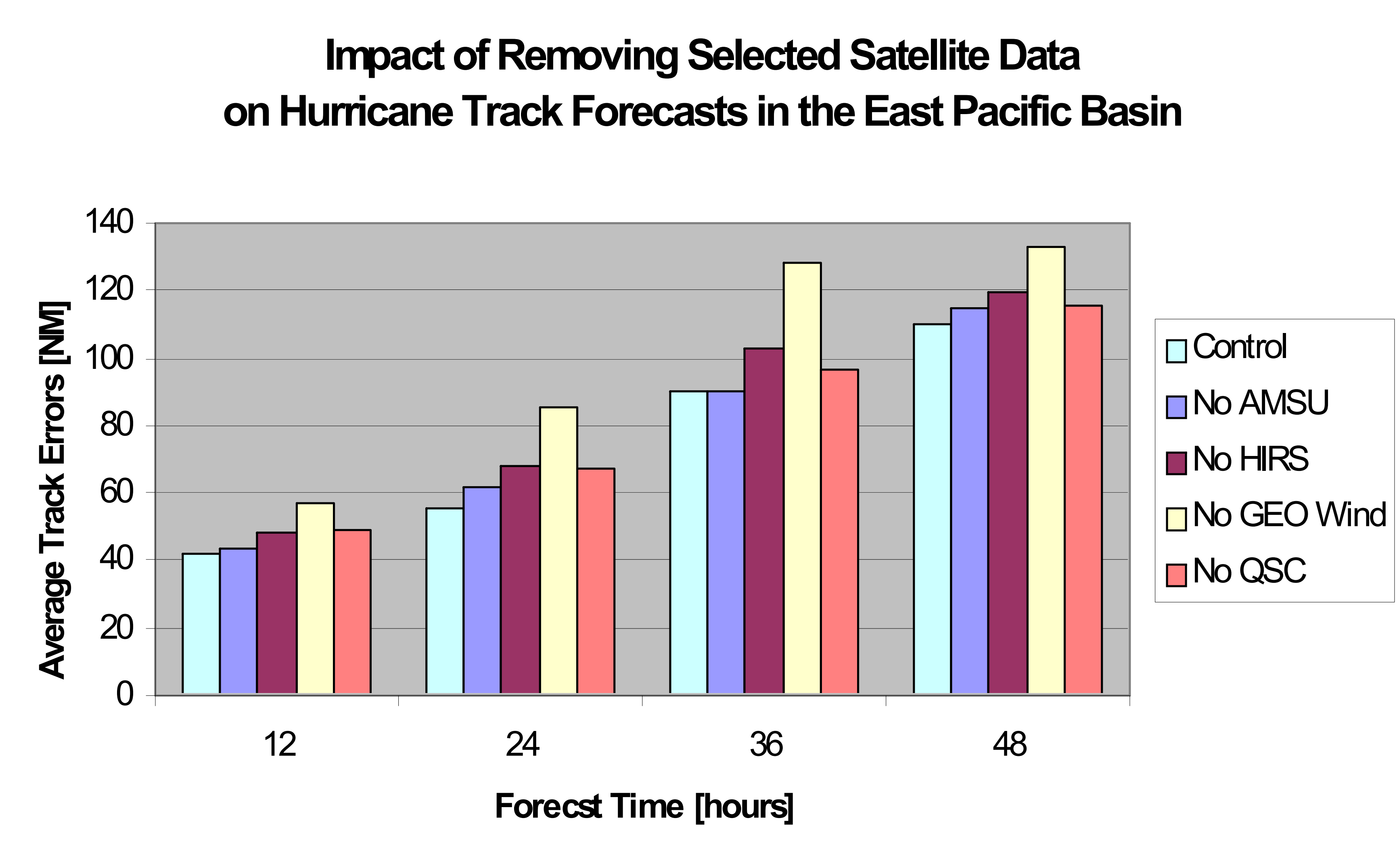
- Background
- The Challenge
- The JCSDA
- The Satellite Program
- Recent Advances
- Impact of Satellite Data
- Plans/Future Prospects
- Summary

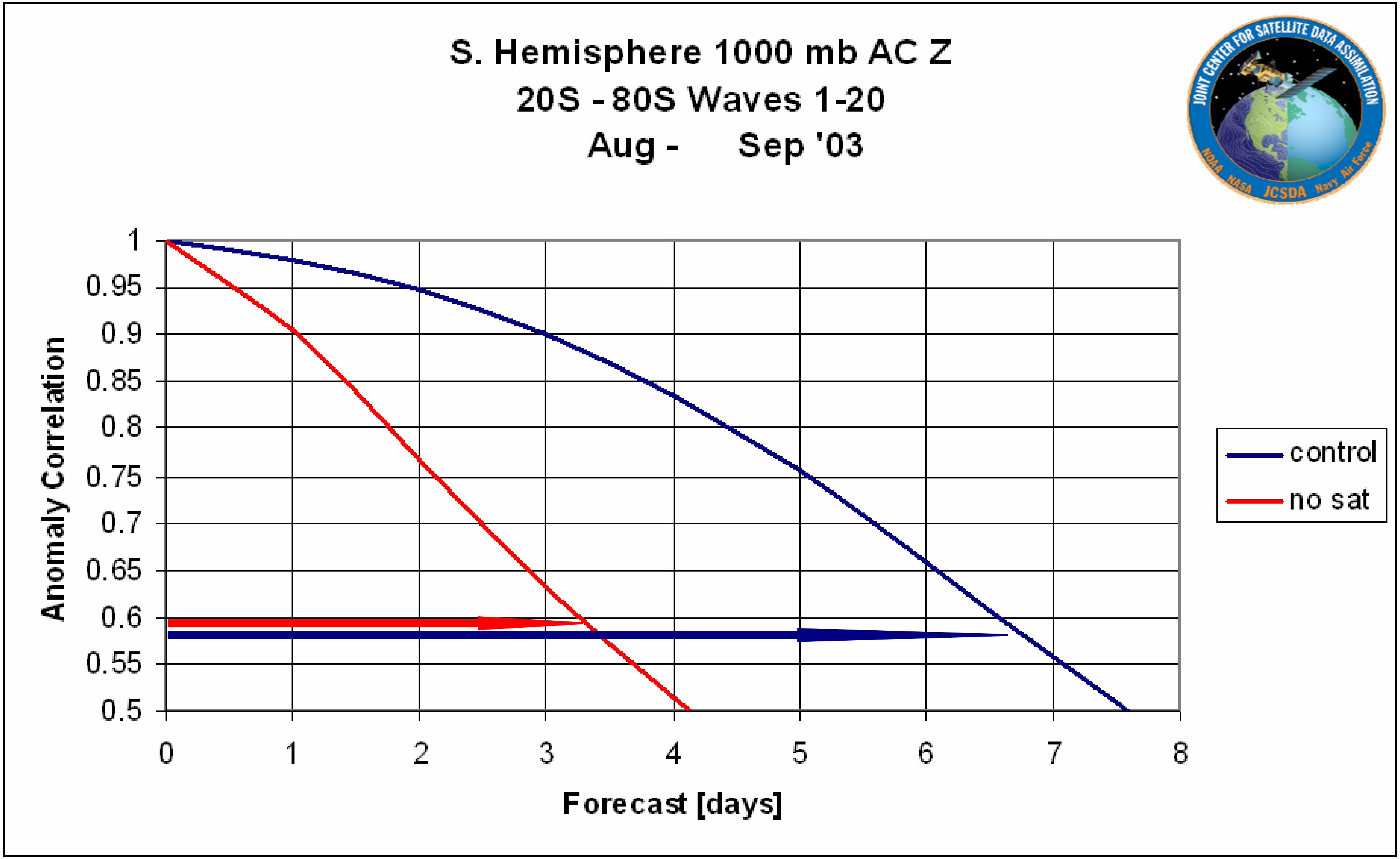

CDAS/Reanl vs GFS
NH/SH 500Hpa day 5
Anomaly Correlation (20-80 N/S)
NH GFS
SH GFS
NH CDAS/Reanl
SH CDAS/Reanl
Anomaly Correlation
90
85
80
75
70
65
60
55
50
45
40
1960
1970
1980
1990
2000
YEAR

Data Assimilation Impacts in the NCEP GDAS



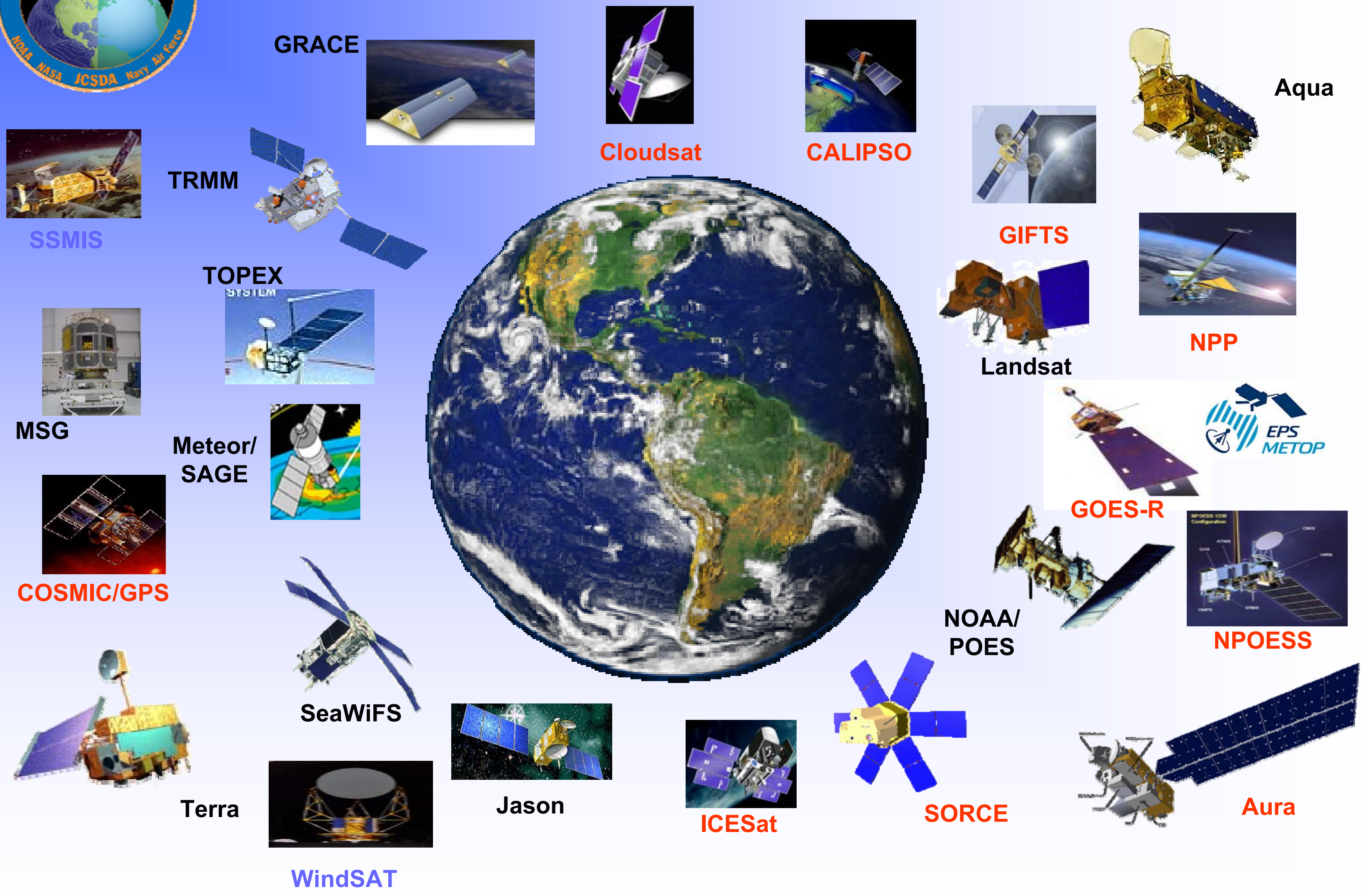
AMSU and "All Conventional" data provide nearly the same amount of improvement to the Northern Hemisphere.


Impact of Removing Selected Satellite Data
on Hurricane Track Forecasts in the East Pacific Basin
Average Track Errors [NM]
140
120
100
80
60
40
20
0
12
24
36
48
Forecst Time [hours]
Control
No AMSU
No HIRS
No GEO Wind
No QSC



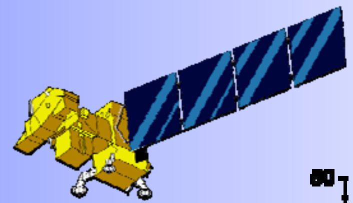
Anomaly correlation for days 0 to 7 for 500 hPa geopotential height in the zonal band 20°-80° for January/February. The red arrow indicate use of satellite data in the forecast model has doubled the length of a useful forecast.

The Challenge
Satellite Systems/Global Measurements

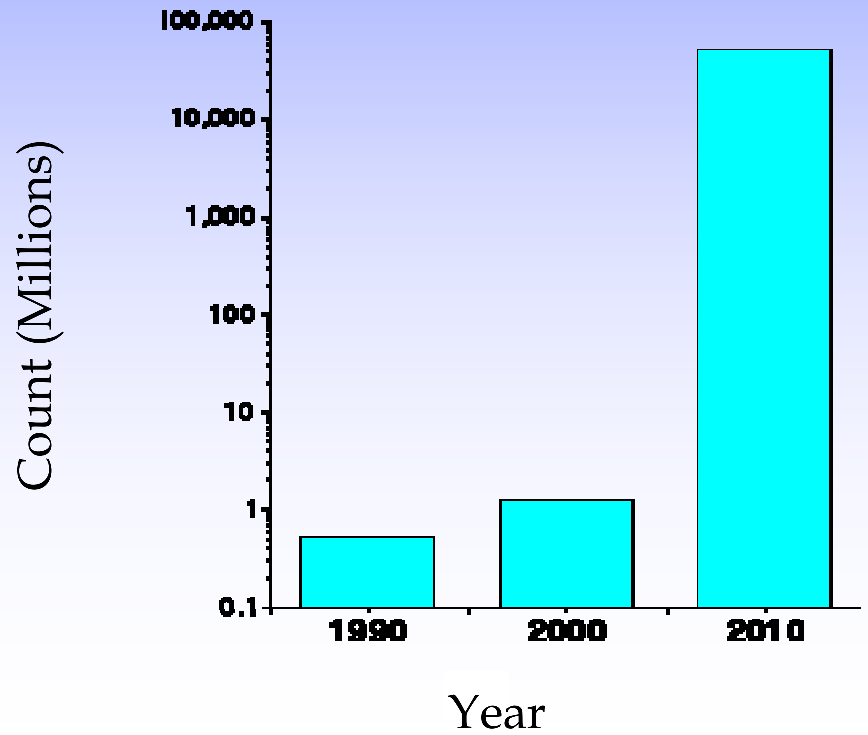


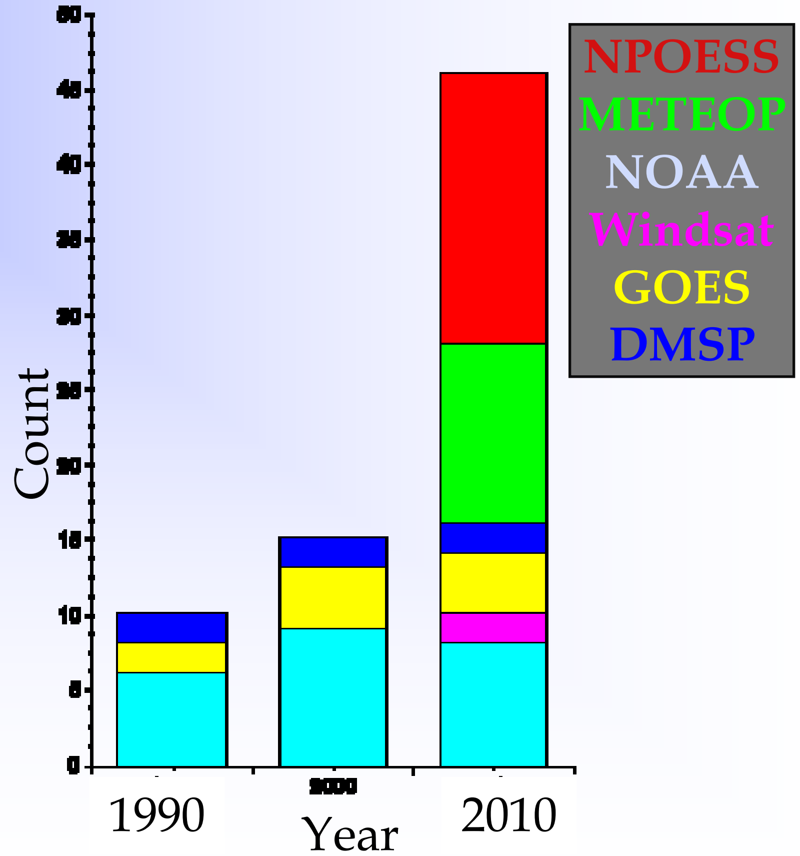
5-Order Magnitude Increase in Satellite Data Over 10 Years

Daily Upper Air Observation Count

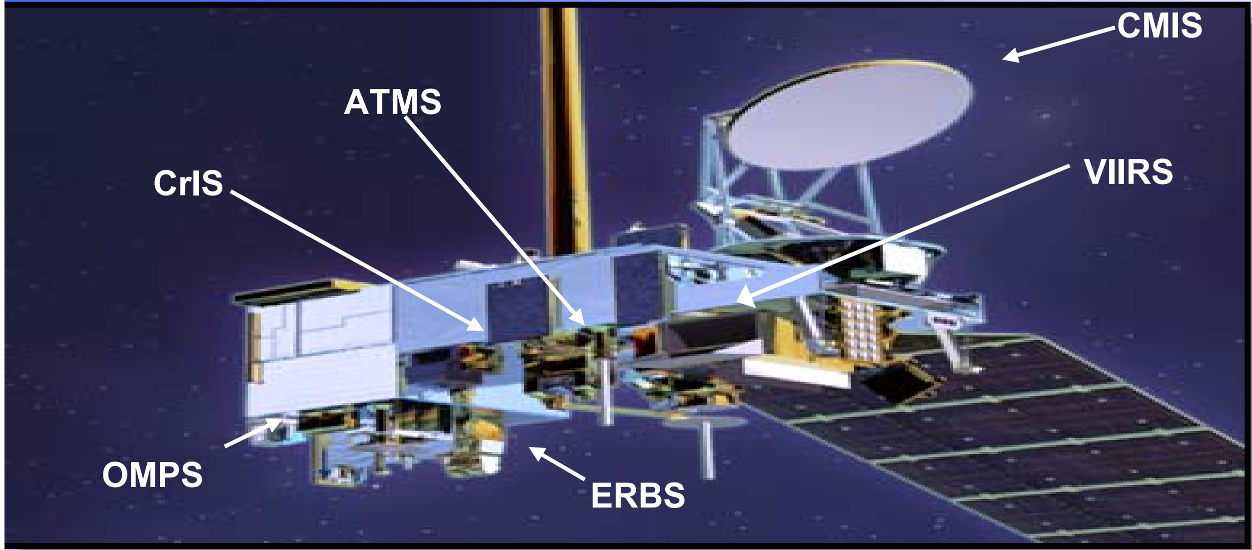


Satellite Instruments by Platform





NPOESS Satellite - Original



CMIS- µwave imager
VIIRS- vis/IR imager
CrIS- IR sounder
ATMS- µwave sounder
OMPS- ozone
GPSOS- GPS occultation
ADCS- data collection
SESS- space environment
APS- aerosol polarimeter
SARSAT - search & rescue
TSIS- solar irradiance
ERBS- Earth radiation budget
ALT- altimeter
SS- survivability monitor

The NPOESS spacecraft has the requirement to operate in three different sun synchronous orbits, 1330, 2130 and 1730 with different configurations of fourteen different environmental sensors that provide environmental data records (EDRs) for space, ocean/water, land, radiation clouds and atmospheric parameters.

In order to meet this requirement, the prime NPOESS contractor, Northrop Grumman Space Technology, is using their flight-qualified NPOESS T430 spacecraft. This spacecraft leverages extensive experience on NASA's EOS Aqua and Aura programs that integrated similar sensors as NPOESS.

As was required for EOS, the NPOESS T430 structure is an optically and dynamically stable platform specifically designed for earth observation missions with complex sensor suites.

In order to manage engineering, design, and integration risks, a single spacecraft bus for all three orbits provides cost-effective support for accelerated launch call-up and operation requirement changes. In most cases, a sensor can be easily deployed in a different orbit because it will be placed in the same position on the any spacecraft. There are ample resource margins for the sensors, allowing for compensation due to changes in sensor requirements and future planned improvements.

The spacecraft still has reserve mass and power margin for the most stressing 1330 orbit, which has eleven sensors. The five panel solar array, expandable to six, is one design, providing power in the different orbits and configurations.

GOES - R

ABI – Advanced Baseline Imager
Total radiances over 24 hours = 172, 500, 000, 000

GS – GOES Sounder

SEISS – Space Environment In-Situ Suite including the Magnetospheric Particle Sensor (MPS); Energetic Heavy Ion Sensor (EHIS); Solar & Galactic Proton Sensor (SGPS)

SIS – Solar Imaging Suite including the Solar X-Ray Imager (SXI); Solar X-Ray Sensor (SXS); Extreme Ultraviolet Sensor (EUVS)

GLM – GEO Lightning Mapper

The Center

History

April 2000, a small team of senior NASA and NOAA managers release a white paper[1] containing plans to improve and increase the use of satellite data for global numerical weather models.

The white paper provided a specific recommendation to establish a Joint Center for Satellite Data Assimilation (JCSDA).

This white paper came in response to a growing urgency for more accurate and improved weather and climate analyses and forecasts.

These improvements could only be made possible by the development of improved models and data assimilation techniques, which allow models to utilize more and better quality data.

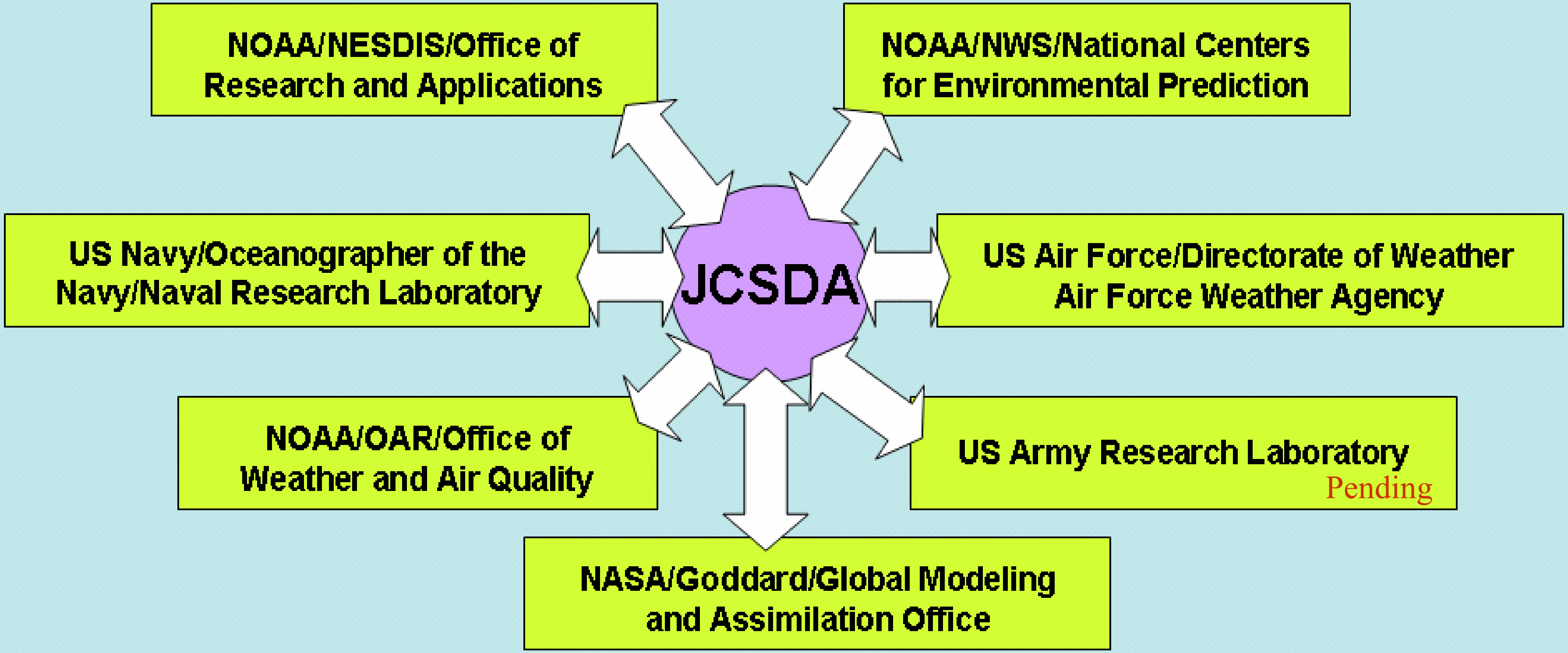
[1] *A NASA and NOAA plan to maximize the utilization of satellite data to improve weather forecasts. Franco Einaudi, Louis Uccellini, James F. W. Purdom, Alexander Mac Donald, April 2000.*

History

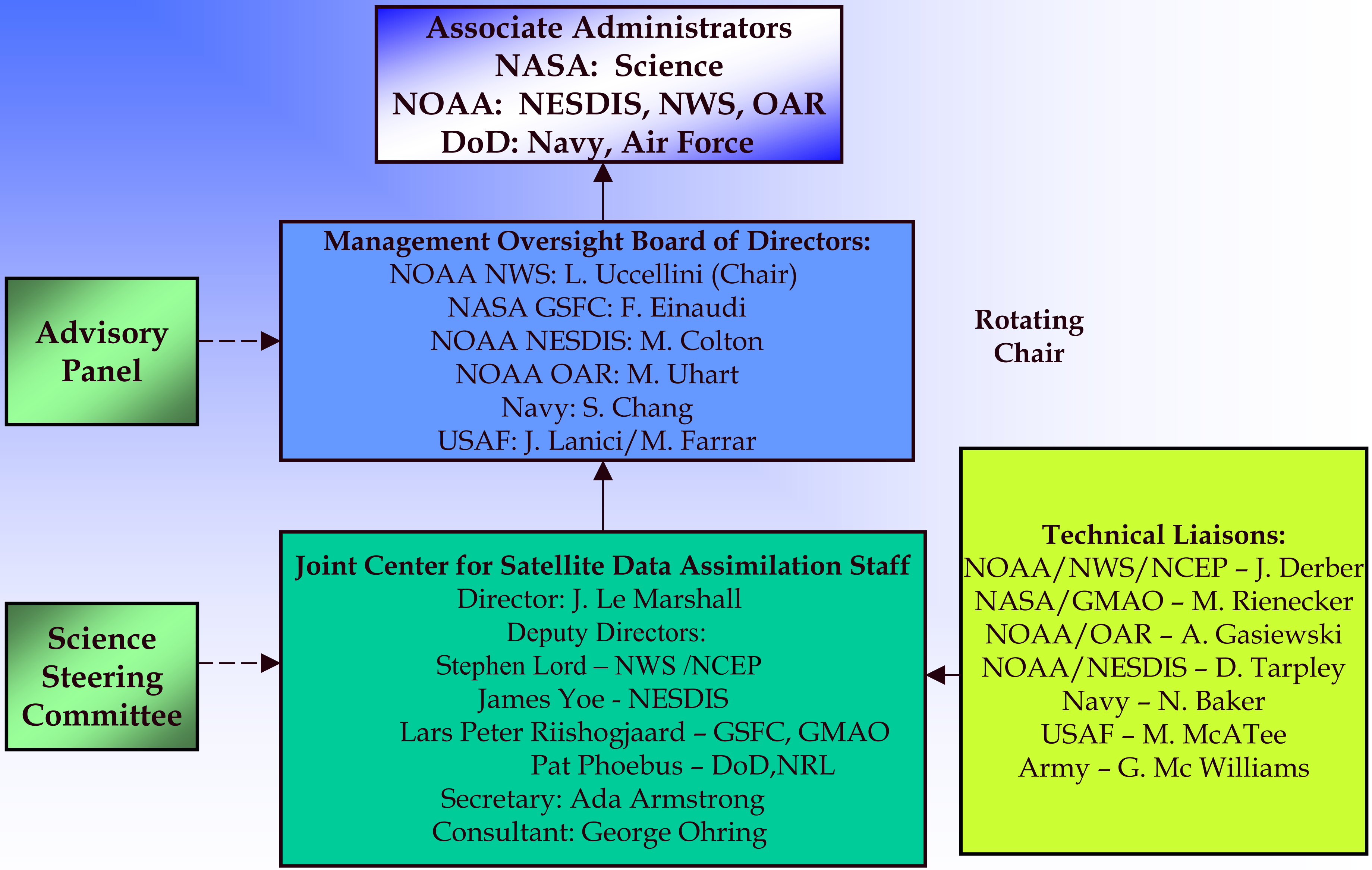
In 2001 the Joint Center was established[2] by NASA and NOAA and in 2002, the JCSDA expanded its partnerships to include the U.S. Navy and Air Force weather agencies.

[2] *Joint Center for Satellite Data Assimilation: Luis Uccellini, Franco Einaudi, James F. W. Purdom, David Rogers: April 2000.*

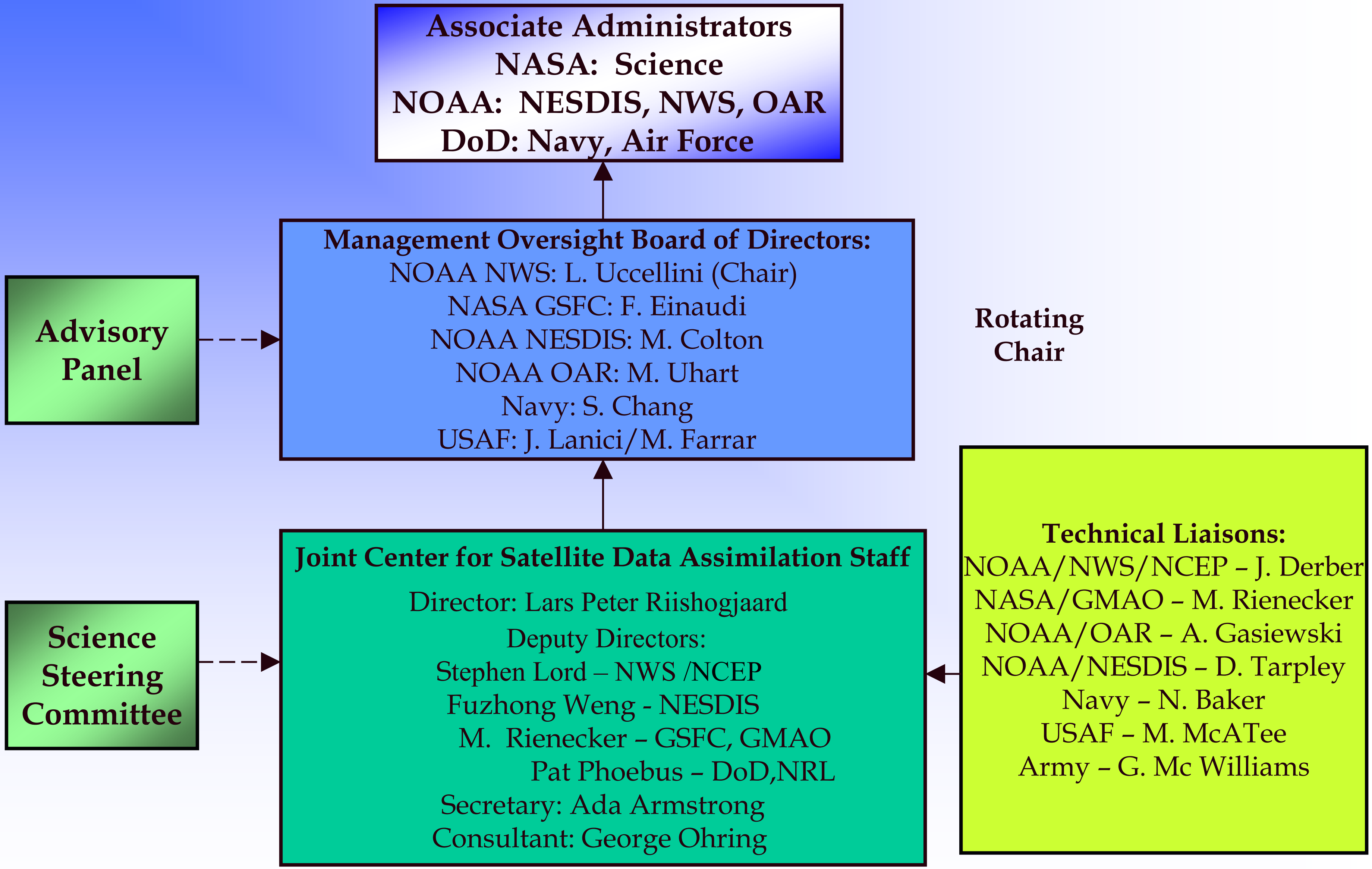
JCSDA Partners



JCSDA Structure



JCSDA Structure



JCSDA Advisory Board

- Provides high level guidance to JCSDA Management Oversight Board

Contributions from

Name	Organization
T Hollingsworth	ECMWF
T. Vonder Haar	CIRA
P. Courtier	Meteo France
E. Kalnay	UMD
R. Anthes	UCAR
J. Purdom	CIRA
P. Rizzoli	MIT

JCSDA Science Steering Committee

- Provides scientific guidance to JCSDA Director
  - Reviews proposals
  - Reviews projects
  - Reviews priorities

Contributions from

Name	Organization
P. Menzel (Chair)	NESDIS
R. Atlas	AOML
C. Bishop	NRL
R. Errico	GSFC
J. Eyre	UK Met Office
S. English	UK Met Office
L. Garand	CMC
A. McNally	ECMWF
G. Kelly	ECMWF
S.Koch	ESRL
B. Navasques	KNMI
F. Toepfer	NWS
A. Busalacchi	ESSIC

JCSDA Technical Liaisons

- Technical Liaisons

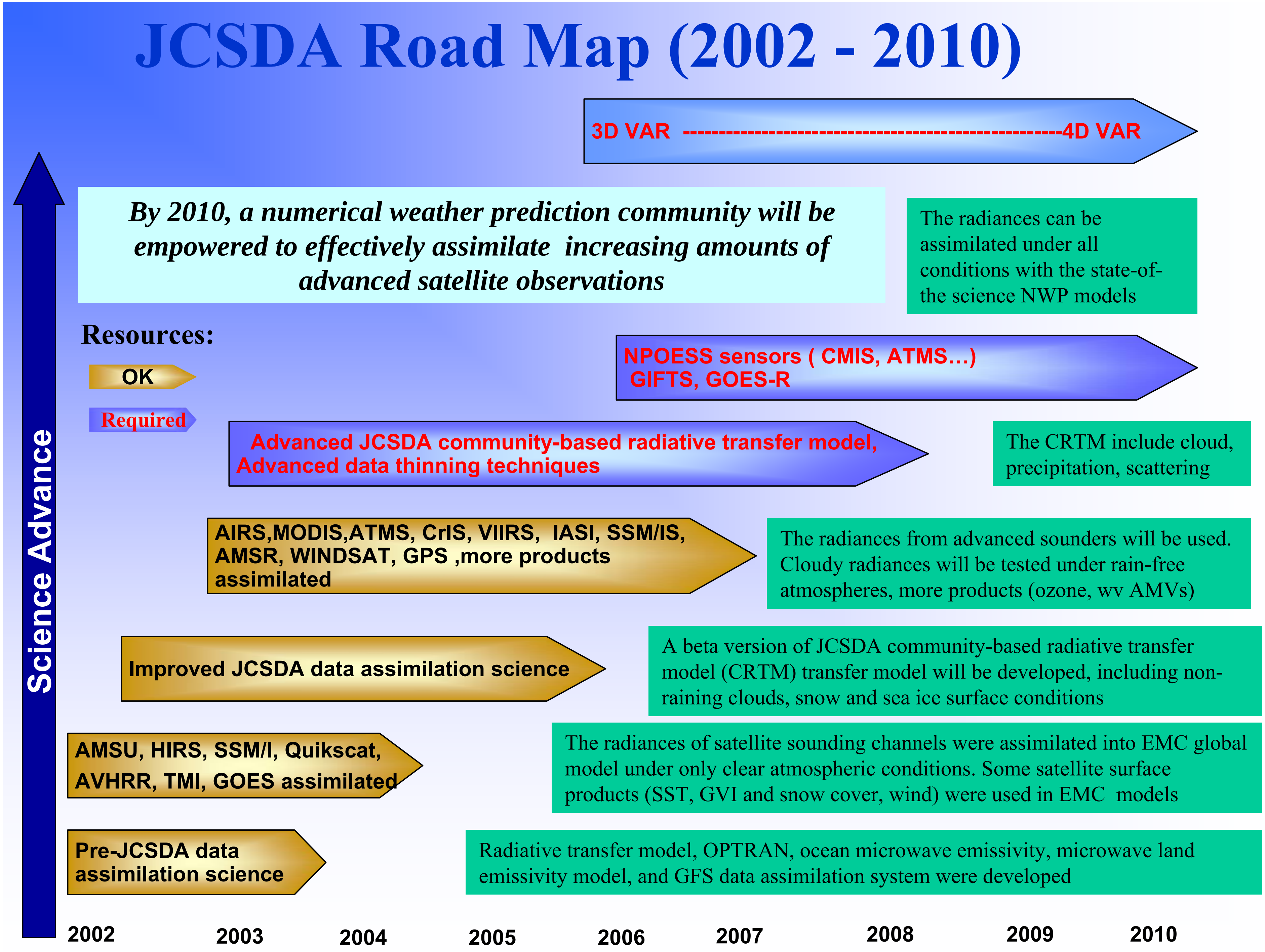
  - Represent their organizations
  - Review proposals and project progress
  - Interact with principal investigators

JCSDA Technical Liaisons	
Liaison Name	**Organization**
J. Derber	EMC
M. Rienecker	GMAO
A. Gasiewski	OWAQR
D. Tarpley	ORA
N. Baker	NRL
M. McAtee	AFWA

JCSDA Mission and Vision

- Mission: Accelerate and improve the quantitative use of research and operational satellite data in weather. ocean, climate and environmental analysis and prediction models

- Vision: A weather, ocean, climate and environmental analysis and prediction community empowered to effectively assimilate increasing amounts of advanced satellite observations and to effectively use the integrated observations of the GEOSS



JCSDA Road Map (2002 - 2010)
3D VAR --4D VAR
By 2010, a numerical weather prediction community will be empowered to effectively assimilate increasing amounts of advanced satellite observations
The radiances can be assimilated under all conditions with the state-of-the science NWP models
Resources:
OK
Required
NPOESS sensors (CMIS, ATMS…) GIFTS, GOES-R
Advanced JCSDA community-based radiative transfer model, Advanced data thinning techniques
The CRTM include cloud, precipitation, scattering
AIRS,MODIS,ATMS, CrIS, VIIRS, IASI, SSM/IS, AMSR, WINDSAT, GPS ,more products assimilated
The radiances from advanced sounders will be used. Cloudy radiances will be tested under rain-free atmospheres, more products (ozone, wv AMVs)
Improved JCSDA data assimilation science
A beta version of JCSDA community-based radiative transfer model (CRTM) transfer model will be developed, including non-raining clouds, snow and sea ice surface conditions
AMSU, HIRS, SSM/I, Quikscat, AVHRR, TMI, GOES assimilated
The radiances of satellite sounding channels were assimilated into EMC global model under only clear atmospheric conditions. Some satellite surface products (SST, GVI and snow cover, wind) were used in EMC models
Pre-JCSDA data assimilation science
Radiative transfer model, OPTRAN, ocean microwave emissivity, microwave land emissivity model, and GFS data assimilation system were developed
Science Advance
2002
2003
2004
2005
2006
2007
2008
2009
2010

JCSDA SCIENCE PRIORITIES

- **Science Priority I - Improve Radiative Transfer Models**

  - Atmospheric Radiative Transfer Modeling – The Community Radiative Transfer Model (CRTM)
  - Surface Emissivity Modeling

- **Science Priority II - Prepare for Advanced Operational Instruments**

- **Science Priority III -Assimilating Observations of Clouds and Precipitation**
  - Assimilation of Precipitation
  - Direct Assimilation of Radiances in Cloudy and Precipitation Conditions

- **Science Priority IV - Assimilation of Land Surface Observations from Satellites**

- **Science Priority V - Assimilation of Satellite Oceanic Observations**

- **Science Priority VI – Assimilation for air quality forecasts**

Strat. Plan/JTOPS

Goals – Short/Medium Term

- Increase uses of current and future satellite data in Numerical Weather and Climate Analysis and Prediction models
- Develop the hardware/software systems needed to assimilate data from the advanced satellite sensors
- Advance common NWP models and data assimilation infrastructure
- Develop a common fast radiative transfer system(CRTM)
- Assess impacts of data from advanced satellite sensors on weather and climate analysis and forecasts (OSEs,OSSEs)
- Reduce the average time for operational implementations of new satellite technology from two years to one

Major Accomplishments

- Common assimilation infrastructure at NOAA and NASA
- Community radiative transfer model
- Common NOAA/NASA land data assimilation system
- Interfaces between JCSDA models and external researchers
- Snow/sea ice emissivity model – permits 300% increase in sounding data usage over high latitudes – improved polar forecasts
- MODIS winds, polar regions, - improved forecasts - Implemented
- AIRS radiances assimilated – improved forecasts – Implemented
- COSMIC data assimilated – improved forecasts - Implemented
- Improved physically based SST analysis - Implemented
- Preparation for advanced satellite data such as METOP (IASI,AMSU,MHS…), , NPP (CrIS, ATMS….), NPOESS, GOES-R data underway.
- Advanced satellite data systems such as DMSP (SSMIS), CHAMP GPS, WindSat tested for implementation.
- Impact studies of POES AMSU, HIRS, EOS AIRS/MODIS, DMSP SSMIS, WindSat, CHAMP GPS on NWP through EMC parallel experiments active
- Data denial experiments completed for major data base components in support of system optimisation
- OSSE studies completed – New OSSE studies underway
- Strategic plans of all Partners include 4D-VAR

JCSDA Instrument Database – June 2006

KEY

(green)	**Current Operations (*= Assimilated in NWP**
(orange)	**Current Testing/Monitoring (Priority 1)**
(red)	**Current Instrument Failure**
(white)	**Not used / Monitoring (Other)**
(cyan)	**Operations Near Future**
(light blue)	**Future (Priority 1)**
(blue)	**Future (Priority 2-3)**

JCSDA Instrument database

			Wavelength				Primary Information Content										JCSDA Partner Priorities				
Platform	Instrument	Status	UV	Visible	IR	Microwave	Temperature	Humidity	Cloud	Precipitation	Wind	Ozone	Land Surface	Ocean Surface	Aerosols	Earth Radiation Budget					
DMSP	**F-13**	Current																			
	SSM/I *					×		v	v	v	v		v	v			1	1	1	1	1
	SSM/T					×	v										3	3	3	3	2
	SSM/T-2					×		v		v							3	3	3	3	2
	F-14	Current																			
	SSM/I *					×		v	v	v	v		v	v			1	1	1	1	1
	SSM/T					×	v										3	3	3	3	2
	SSM/T-2					×		v		v							3	3	3	3	2
	F-15	Current																			
	SSM/I *					×		v	v	v	v		v	v			1	1	1	1	1
	SSM/T					×	v										3	3	3	3	2
	SSM/T-2					×		v		v							3	3	3	3	2
	F-16	Current																			
	SSM/T					×	v										3	3	3	3	2
	SSM/T-2					×		v		v							3	3	3	3	2
	SSMI/S																2	1	2	1	1
	OLS			×	×				v				v	v			3	2	3		2
POES	**NOAA-14**	Current																			
	MSU*					×	v	v	v	v			v	v			1	1	1	1	1
	HIRS/2 *				×		v	v	v			v	v	v		v	1	1	1	1	1
	AVHRR *			×	×				v				v	v	v	v		1		1	2
	SBUV/2 *		×									v					1	1	1	1	2
	SEM																				
	DCS																				
	SARSAT																				
	NOAA-15	Current																			
	AMSU-A *					×	v	v	v	v			v	v			1	1	1	2	1
	AMSU-B *					×		v		v							1	1	1	1	1
	HIRS/3 *				×		v	v	v			v	v	v		v	1	1	1	1	1
	AVHRR/3 *			×	×				v				v	v	v	v		1		1	2
	SEM/2																				
	DCS																				
	SARSAT																				
	NOAA-16	Current																			
	AMSU-A *					×	v	v	v	v			v	v			1	1	1	2	1
	AMSU-B *					×		v		v							1	1	1	1	1
	HIRS/3 *				×		v	v	v			v	v	v		v	1	1	1	1	1
	AVHRR/3 *			×	×				v				v	v	v	v		1		1	2
	SBUV/2 *											v					1	1	1	1	2
	SEM/2																				
	DCS																				
	SARSAT																				
	NOAA-17	Current																			
	AMSU-A *					×	v	v	v	v			v	v			1	1	1	2	1
	AMSU-B *					×		v		v							1	1	1	1	1
	HIRS/3 *				×		v	v	v			v	v	v		v	1	1	1	1	1
	AVHRR /3*			×	×				v				v	v	v	v		1		1	2
	SBUV/2 *											v					1	1	1	1	2
	SEM/2																				
	DCS																				
	SARSAT																				
	NOAA-18	Current																			
	AMSU-A *					×	v	v	v	v			v	v			1	1	1	2	1
	AVHRR *			×	×				v				v	v	v	v		1		1	2
	SBUV *											v					1	1	1	1	2
	HIRS/4 *						v	v	v			v	v	v		v	1	1	1	1	1
	MHS							v	v	v			v				1	1	1	1	1
GOES	Imager *	Current		×	×				v		v			v			1	1	1	1	1
	Sounder *			×	×		v	v	v		v		v	v			3	1	3	1	2

METEOSAT	Imager	Current		×	×				v		v	v	v	v			1	1	1	1	1
GFO	Altimeter*	Current									v			v			1	1	1	1	1
MTSAT	Imager *	Current		×	×		v	v	v		v		v	v	v		1	1	3	1	1
Terra	MODIS*	Current		×	×		v	v	v	v	v		v	v	v		2	1	2	1	1
TRMM	TMI*	Current				×		v	v	v	v		v	v			2	2	2	2	1
	VIRS			×	×	×			v					v	v		3	2	3	2	2
	PR					×				v							3	2	3	2	1
	CERES		×	×	×	×										v	3	3	3	3	3
QuikSCAT	Scatterometer *	Current				×					v		v				1	1	1	1	1
TOPEX	Altimeter *	Current				×		TPW			v			v			1	1	1	1	1
JASON-1	Altimeter	Current				×		TPW			v			v			1	1	1	1	1
AQUA	AMSR-E	Current		×	×	×		v	v	v	v		v	v			1	1	1	1	1
	AMSU*						v	v	v	v			v	v			1	1	1	1	1
	HSB							v		v				v			3		3		2
	AIRS*						v	v	v			v	v	v			1	1	1	1	1
	MODIS*						v	v	v	v	v		v	v	v		2	1	1	1	1
Envisat	Altimeter*	Current				×		v		v	v			v			1	1	1	1	1
	MWR					×		v	v								2	1	2	1	1
	MIPAS				×		v					v					2	2	2	2	2
	AATSR													v			2	1	2	1	2
	MERIS								v				v	v	v		2	2	2	2	1
	SCIAMACHY							v	v			v			v		3	3	3	3	3
	GOMOS											v					2	1	2	1	2
Windsat	Polarimetric radiometer	Current				×	SST	TPW		v	v		v	v			2	1	2	1	1
Aura	OMI	Current										v					1	1	1	1	2
	MLS											v					2	2	2	2	2
INSAT-3D	Imager	2007						v	v	v	v		v	v	v						
	Sounder						v	v	v		v		v	v							
FY-1	MVISR	Current					v	v	v	v	v			v	v						
FY- 2	VISSR	Current						v	v		v		v	v	v						
CHAMP	GPS	Current					v	v									1	2	1	2	1
COSMIC	GPS	Current				×	v	v									1	2	1	2	1
METOP	IASI	2006			×		v	v	v			v	v	v			1	1	1	1	1
	ASCAT					×					v		v	v			1	1	1	1	1
	GRAS					×	v	v									1	2	1	2	3
	HIRS				×		v	v	v			v	v	v			1	1	1	1	1
	AMSU						v	v	v	v			v	v			1	1	1	1	1
	MHS							v		v							1	1	1	1	1
	GOME-2											v					1	1	1	1	2
	AVHRR			×	×		SST		v	v			v	v	v		1	1	1	1	1
NPP	VIIRS	2009		×	×		SST		v		Polar		v	v	v		1	1	1	1	1
	CRIS				×		v	v	v			v	v	v			1	1	1	1	1
	OMPS																1	1	1	1	1
	ATMS					×	v	v	v	v			v	v			1	1	1	1	1
EO-3/IGL	GIFTS	2009			×		v	v	v	v	v	v	v	v			1	2	2	2	1
SMOS	MIRAS	2007				×							v	v			1	2	1	2	1
NPOESS	VIIRS	2013		×	×		SST	TPW	v		Polar		v	v	v		1	1	1	1	1
	CRIS				×		v	v	v			v	v	v			1	1	1	1	1
	ATMS					×	v	v	v	v			v	v			1	1	1	1	1
	CMIS					×	v	v	v	v	v		v	v			1	1	1	1	1
	GPSOS					×	v	v									1	2	1	2	2
	APS														v		2	1	1	1	2
	ERBS															v	3	3	3	3	3
	Altimeter										v			v			1	1	1	1	1
	OMPS		×									v					1	1	1	1	1
	SEM																				
	TSIS																				
ADM	Doppler lidar	2009		×							v						1	1	1	1	1
GPM	GMI	2010				×				v	v		v				2	2	2	2	1
	DPR					×				v							2	2	2	2	1
GOES R	ABI	2012		×	×				v	v	v		v	v	v		1	1	1	1	1
	HES				×		v	v	v		v	v	v	v			1	1	1	1	1
	DWL	2013	*		*				v		v				v		1				

Satellite Data used in NWP

- HIRS sounder radiances
- AMSU-A sounder radiances
- AMSU-B sounder radiances
- GOES sounder radiances
- GOES, Meteosat, GMS winds
- GOES precipitation rate
- SSM/I precipitation rates
- TRMM precipitation rates
- SSM/I ocean surface wind speeds
- ERS-2 ocean surface wind vectors
- COSMIC data
- WindSat
- Quikscat ocean surface wind vectors
- AVHRR SST
- AVHRR vegetation fraction
- AVHRR surface type
- Multi-satellite snow cover
- Multi-satellite sea ice
- SBUV/2 ozone profile and total ozone
- Altimeter sea level observations (ocean data assimilation)
- AIRS
- MODIS Winds
- …

>36 instruments –ops

>40 instruments - tested

Sounding data used operationally within the GMAO/NCEP Global Forecast System

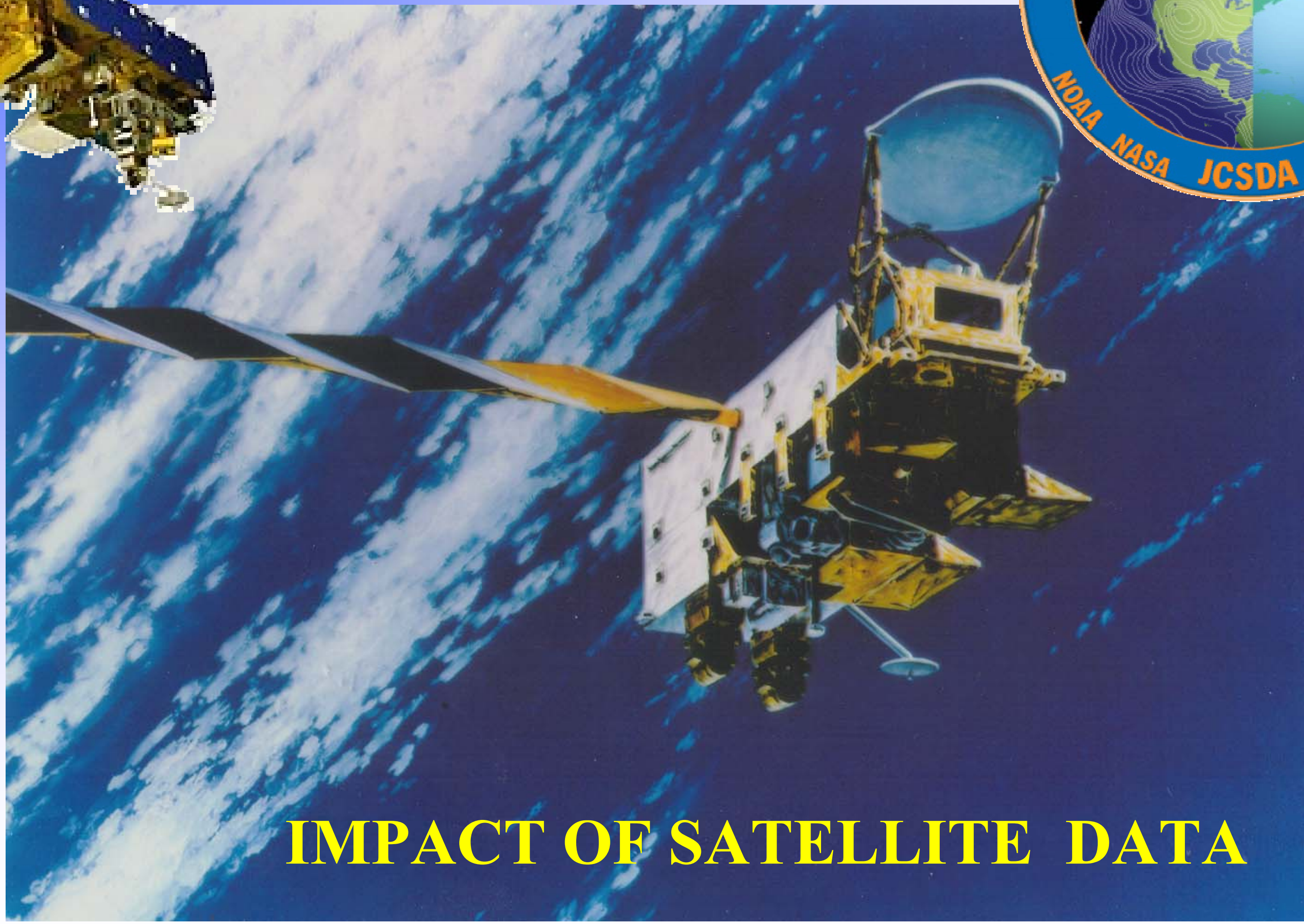
AIRS	On
HIRS sounder radiances	14 - off
	15 - off
	16 - off
	17 - on
	METOP-on
AMSU-A sounder radiances	15 - on
	16 - on
	17 - off
	18 - on
	AQUA
MSU	14 - on
AMSU-B sounder radiances	15 - on
	16 - on
	17 - on
MHS	18 - on
GOES sounder radiances	10 - on
	12 - on
SBUV/2 ozone profile and total ozone	16 - on
	17 - on

Sounding data used operationally within the GMAO/NCEP Global Forecast System

AIRS	On
HIRS sounder radiances	14 - off
	15 - off
	16 - off
	17 - on
	METOP-on
AMSU-A sounder radiances	15 - on
	16 - on
	17 - off
	18 - on
	METOP-on
	AQUA-on
MSU	14 - off
AMSU-B sounder radiances	15 - on
	16 - on
	17 - on
MHS	18 - on
	METOP-on
GOES sounder radiances	10 - on
	12 - on
SBUV/2 ozone profile and total ozone	16 - on
	17 - on

Some Satellite Data in the Process of Being Transitioned into Operations

Satellite/Instrument	Analysis	Comments
CHAMP	GSI NOGAPS	NRT assim. tests completed, awaiting RT data access
WINDSAT	GSI NOGAPS	RT Impact trial,positive impact. NRL Impl.
SSMIS	GSI NOGAPS	Real time testing, positive impact.
MODIS υ.2 (EE)	GSI	EE implemented for intelligent thinning of AMVs
AIRS υ.2 (every fov - 251 channels used)	SSI GSI NOGAPS	GSI testing complete.
AURA OMI	GSI	Total ozone successfully assimilated, still testing
AMSRE(E)	GSI	Positive impact positive in GSI.
METOP IASI	GSI	Preparation for testing
GFO	RTOFS	Assim. tests current.



IMPACT OF SATELLITE DATA

Development and Implementation of the Community Radiative Transfer Model (CRTM)

P. van Delst, Q. Liu, F. Weng, Y. Chen, *D. Groff, B. Yan, N. Nalli,*
R. Treadon, J. Derber and *Y. Han …..*

Community Contributions

- Community Research: Radiative transfer science
  - AER. Inc: Optimal Spectral Sampling (OSS) Method
  - NRL – Improving Microwave Emissivity Model (MEM) in deserts
  - NOAA/ETL – Fully polarmetric surface models and microwave radiative transfer model
  - UCLA – Delta 4 stream vector radiative transfer model
  - UMBC – aerosol scattering
  - UWisc – Successive Order of Iteration
  - CIRA/CU – SHDOMPPDA
  - UMBC SARTA
  - Princeton Univ – snow emissivity model improvement
  - NESDIS/ORA – Snow, sea ice, microwave land emissivity models, vector discrete ordinate radiative transfer (VDISORT), advanced double/adding (ADA), ocean polarimetric, scattering models for all wavelengths
- Core team (JCSDA - ORA/EMC): Smooth transition from research to operation
  - Maintenance of CRTM (OPTRAN/OSS coeff., Emissivity upgrade)
  - CRTM interface
  - Benchmark tests for model selection
  - Integration of new science into CRTM

Major Progress

- CRTM v.1 has been integrated into the GSI at NCEP/EMC (Dec. 2005)

- Beta version CRTM has been released to the public

- CRTM with OSS (Optimal Spectral Sampling) has been preliminarily implemented and is being evaluated and improved.

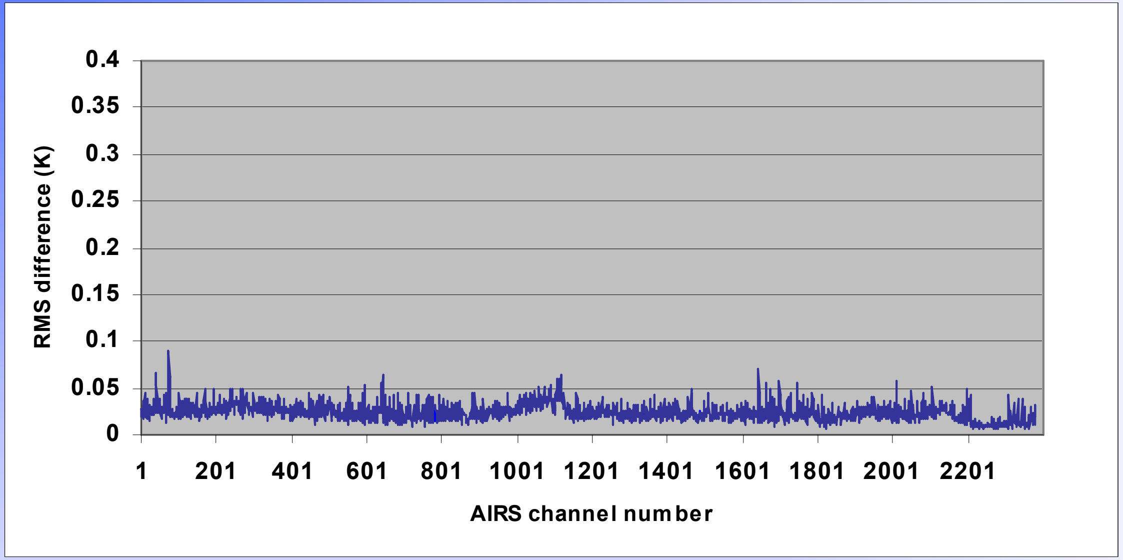
COMMUNITY RADIATIVE TRANSFER MODEL CRTM

Below are some of the instruments for which we currently have transmittance coefficients.

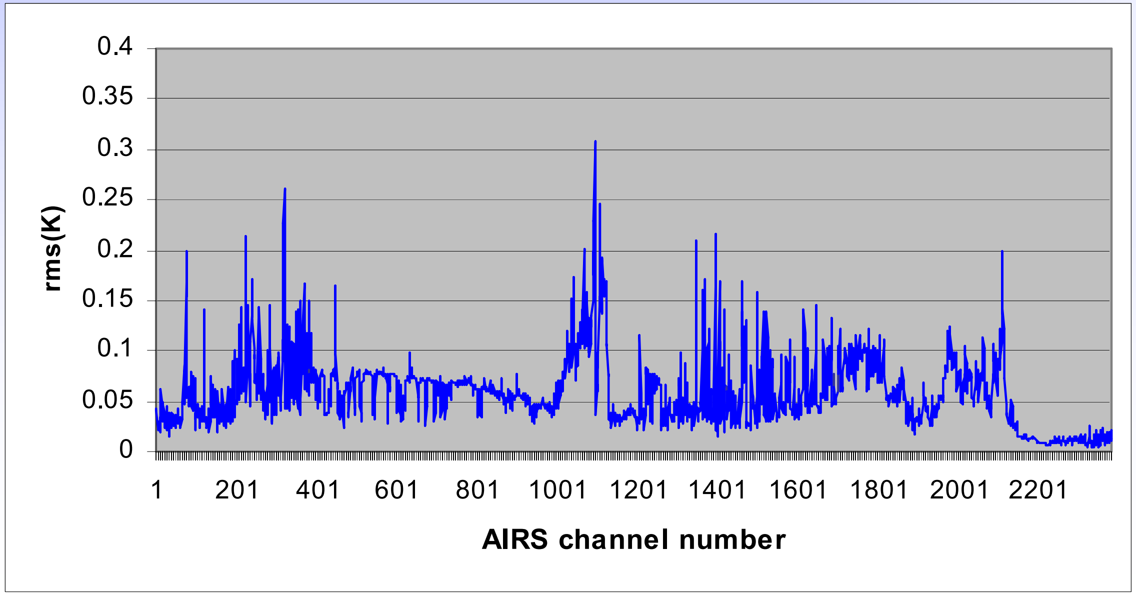
abi_gr (gr == GOES-R) airs_aqua amsre_aqua amsua_aqua amsua_n15 amsua_n16 amsua_n17 amsua_n18 amsub_n15 amsub_n16 amsub_n17 avhrr2_n10 avhrr2_n11 avhrr2_n12 avhrr2_n14 avhrr3_n15 avhrr3_n16 avhrr3_n17 avhrr3_n18 hirs2_n10 hirs2_n11 hirs2_n12 hirs2_n14 hirs3_n15 hirs3_n16 hirs3_n17 hirs3_n18 hsb_aqua imgr_g08 imgr_g09 imgr_g10 imgr_g11 imgr_g12 mhs_n18 modisD01_aqua (D01 == detector 1, D02 == detector 2, etc) modisD01_terra modisD02_aqua modisD02_terra modisD03_aqua modisD03_terra modisD04_aqua modisD04_terra modisD05_aqua modisD05_terra modisD06_aqua modisD06_terra modisD07_aqua modisD07_terra modisD08_aqua modisD08_terra modisD09_aqua modisD09_terra modisD10_aqua modisD10_terra modis_aqua (detector average) modis_terra (detector average) msu_n14 sndr_g08 sndr_g09 sndr_g10 sndr_g11 sndr_g12 ssmi_f13 ssmi_f14 ssmi_f15 ssmis_f16 ssmt2_f14 vissrDetA_gms5 windsat_coriolis

IMPROVED COMMUNITY RADIATIVE TRANSFER MODEL

CRTM OPTRAN-V7 vs. OSS for AIRS channels



OSS



OPTRAN

AREAS REQUIRING CONTINUING ATTENTION

Surface Emissivity

Faster Hyperspectral Calculations

Modelling Cloudy And Precipitating Radiances

Cross Calibration, Bias Correction, Transmittance Tuning

……..

OBSERVING SYSTEM EXPERIMENTS

OBSERVING SYSTEM EXPERIMENT WITH SATELLITE AND CONVENTIONAL DATA

T. Zapotocny, J. Jung. J. Le Marshall, R Treadon, ……

The analysis and forecast model used for these observing system experiments is the NCEP Global Data Assimilation/Forecast System (GDAS/GFS).

The OSE consists of 45-day periods during January-February and August-September 2003. During these periods, a T254 - 64 layer version of NCEP's global spectral model was used.

The control run utilizes NCEP's operational data base and consists of all data types routinely assimilated in the GDAS. The two experimental runs have either all the conventional in-situ data denied (NoCon) or all the remotely sensed satellite data denied (NoSat). Differences between the control and experimental runs are accumulated over the 45-day periods and analyzed to demonstrate the forecast impact of these data types through 168 hours.

Note:geographic distribution of impact also calculated

Table 1. Conventional data denied within the NCEP Global Data Assimilation System for this study. Mass observations (temperature and moisture) are shown in the left hand column while wind observations are shown in the right hand column.

Rawinsonde temperature and humidity	Rawinsonde u and v
AIREP and PIREP aircraft temperatures	AIREP and PIREP aircraft u and v
ASDAR aircraft temperatures	ASDAR aircraft u and v
Flight-level reconnaissance and dropsonde temperature, humidity and station pressure	Flight-level reconnaissance and dropsonde u and v
MDCARS aircraft temperatures	MDCARS aircraft u and v
Surface marine ship, buoy and c-man temperature, humidity and station pressure	Surface marine ship, buoy and c-man u and v
Surface land synoptic and Metar temperature, humidity and station pressure	Surface land synoptic and metar u and v
Ship temperature, humidity and station pressure	Wind Profiler u and v
	NEXRAD Vertical Azimuth Display u and v
	Pibal u and v

Table 2. Satellite data denied within the NCEP Global Data Assimilation System for this study.

HIRS sounder radiances	SBUV ozone radiances
MSU radiances	QuikSCAT surface winds
AMSU-A radiances	GOES atmospheric motion vectors
AMSU-B radiances	GMS atmospheric motion vectors
GOES sounder radiances	METEOSAT atmospheric motion vectors
SSM/I precipitation rate	SSM/I surface wind speed
TRMM precipitation rate	

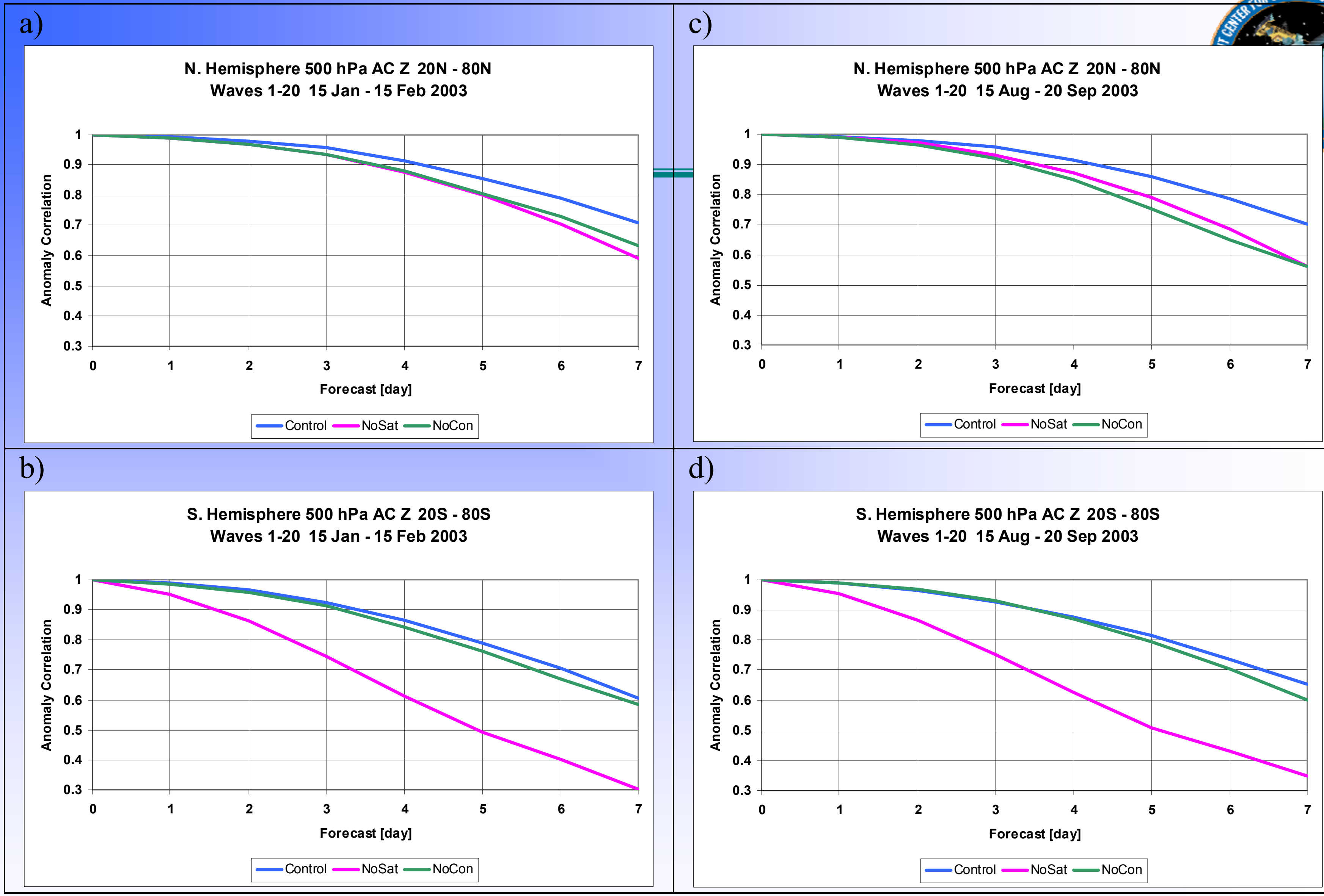
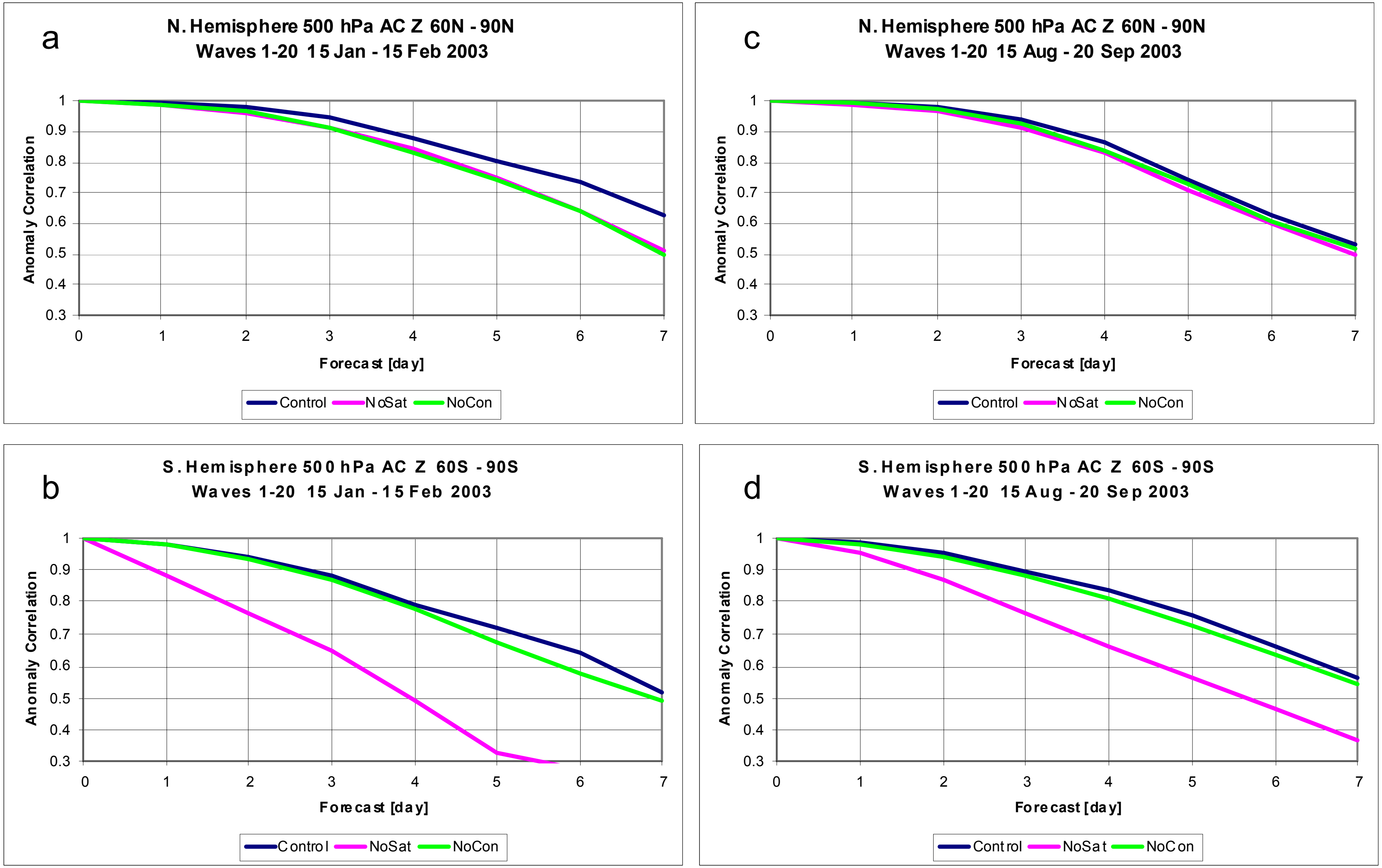


Fig. 6. Anomaly correlation for days 0 to 7 for 500 hPa geopotential height in the zonal band 20°-80° for each Hemisphere and season. The control simulation is shown in blue, while the NoSat and NoCon denial experiments are shown in magenta and green, respectively.



Anomaly correlation for days 0 to 7 for 500 hPa geopotential height in the polar cap regior (60°-90°) of each Hemisphere and season. The control simulation is shown in blue, while the NoSat and NoCon denial experiments are shown in magenta and green, respectively.

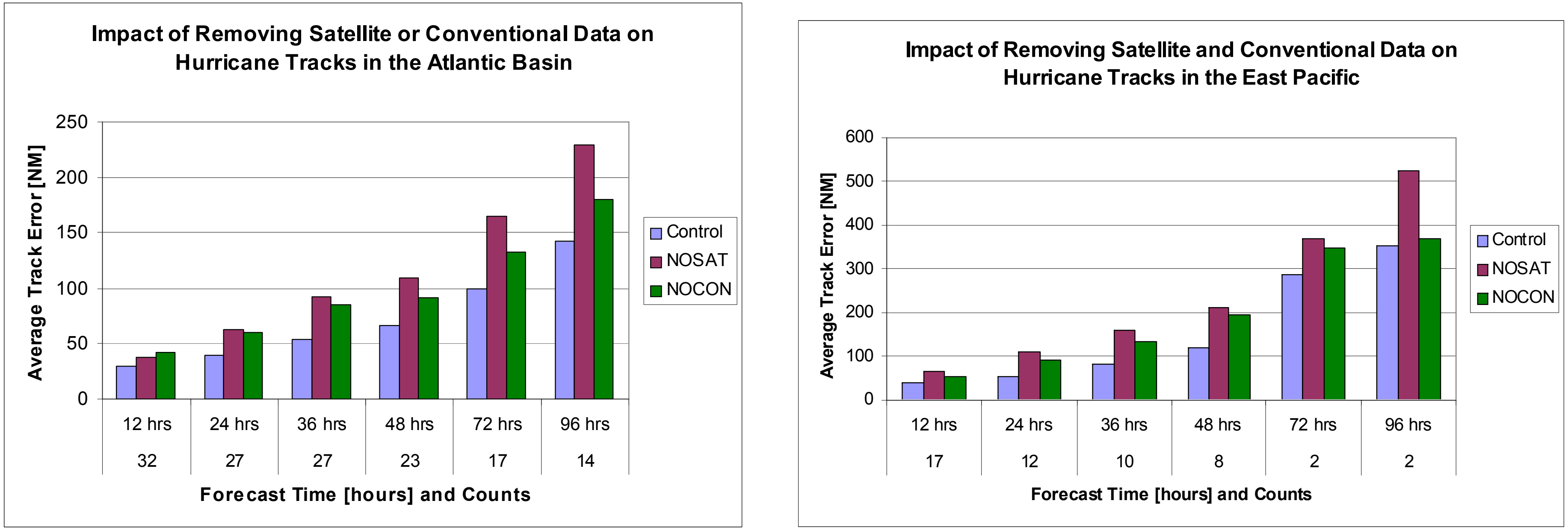


Fig. 7 The impact of removing satellite and in-situ data on hurricane track forecasts in the GFS during the period 15 August to 20 September 2003. Panels (a and b) show the average track error (NM) out to 96 hours for the control experiment and the NoSat and NoCon denials for the Atlantic and Pacific Basins, respectively.

OBSERVING SYSTEM EXPERIMENTS

OBSERVING SYSTEM EXPERIMENT WITH

FOUR SATELLITE DATA TYPES

AND

RAWINSONDE DATA

A series of Observing System Experiments (OSEs) covering two seasons has been undertaken to quantify the contributions to the forecast quality from conventional rawinsonde data and from four types of remotely sensed satellite data.

The impact was measured by comparing the analysis and forecast results from an assimilation/forecast system using all data types in NCEP's operational data base with those from a system excluding a particular observing system.

For these OSEs, the forecast results are compared through 168 hours for periods covering more than a month during two seasons.

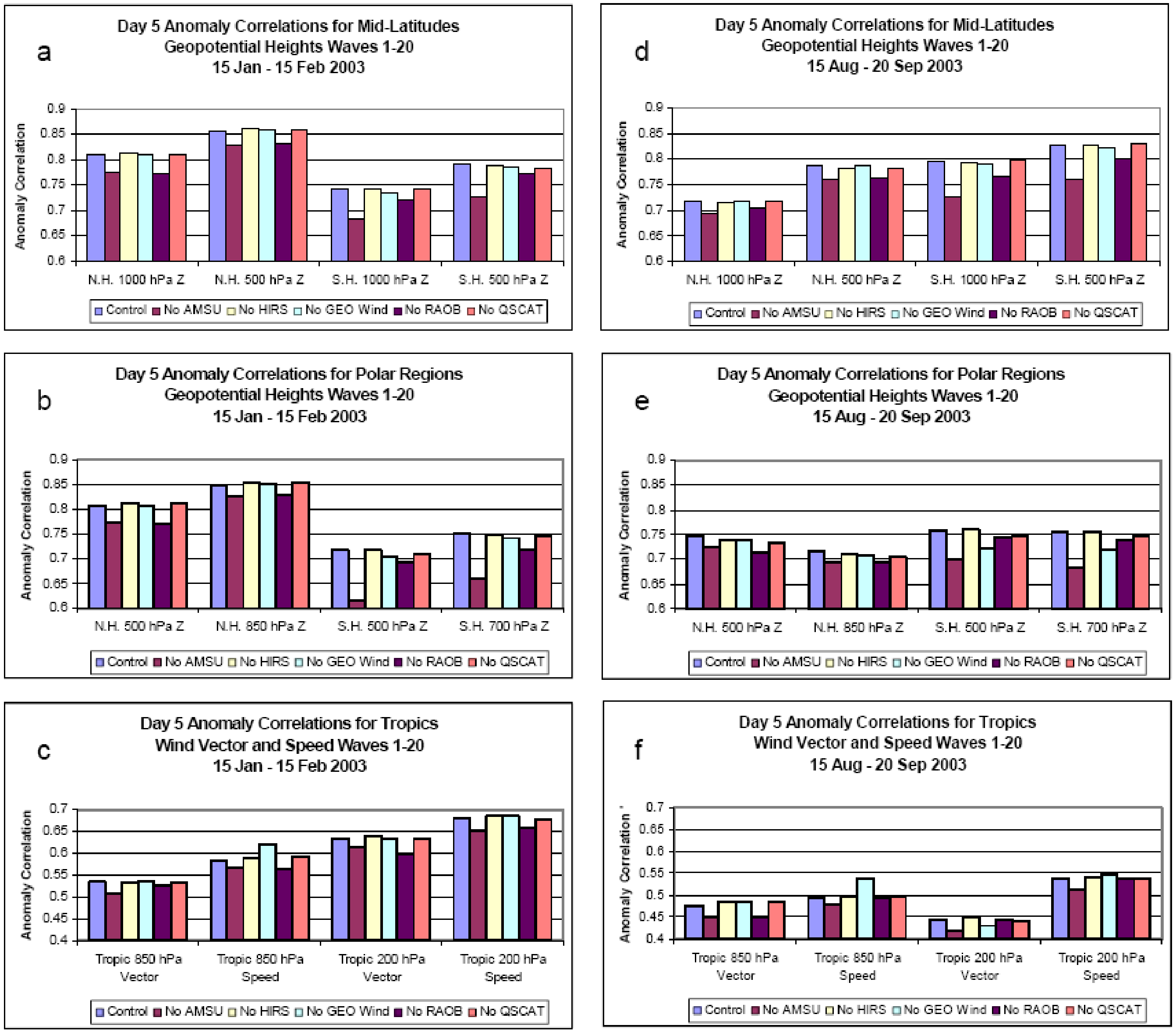


Fig. 8 The day 5 anomaly correlations for waves 1-20 for the (a and d) mid-latitudes, (b and e) polar regions and (c and f) tropics. Experiments shown for each term include, from left to right, the control simulation and denials of AMSU, HIRS, GEO winds, Rawinsondes and QuikSCAT. The 15 January to 15 February 2003 results are shown in the left column and the 15 August to 20 September results are shown in the right column. Note the different vertical scale in (c and f).

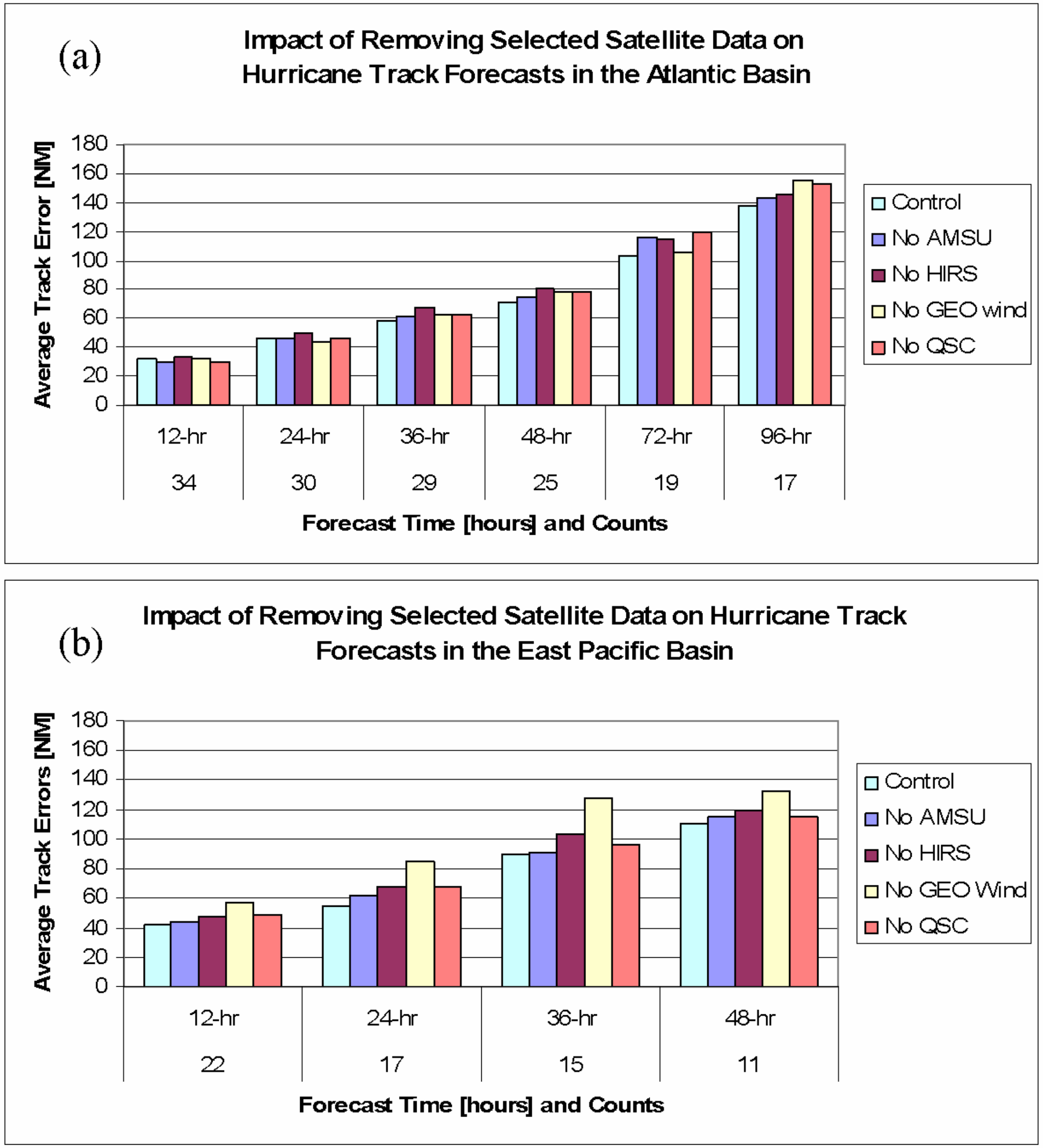


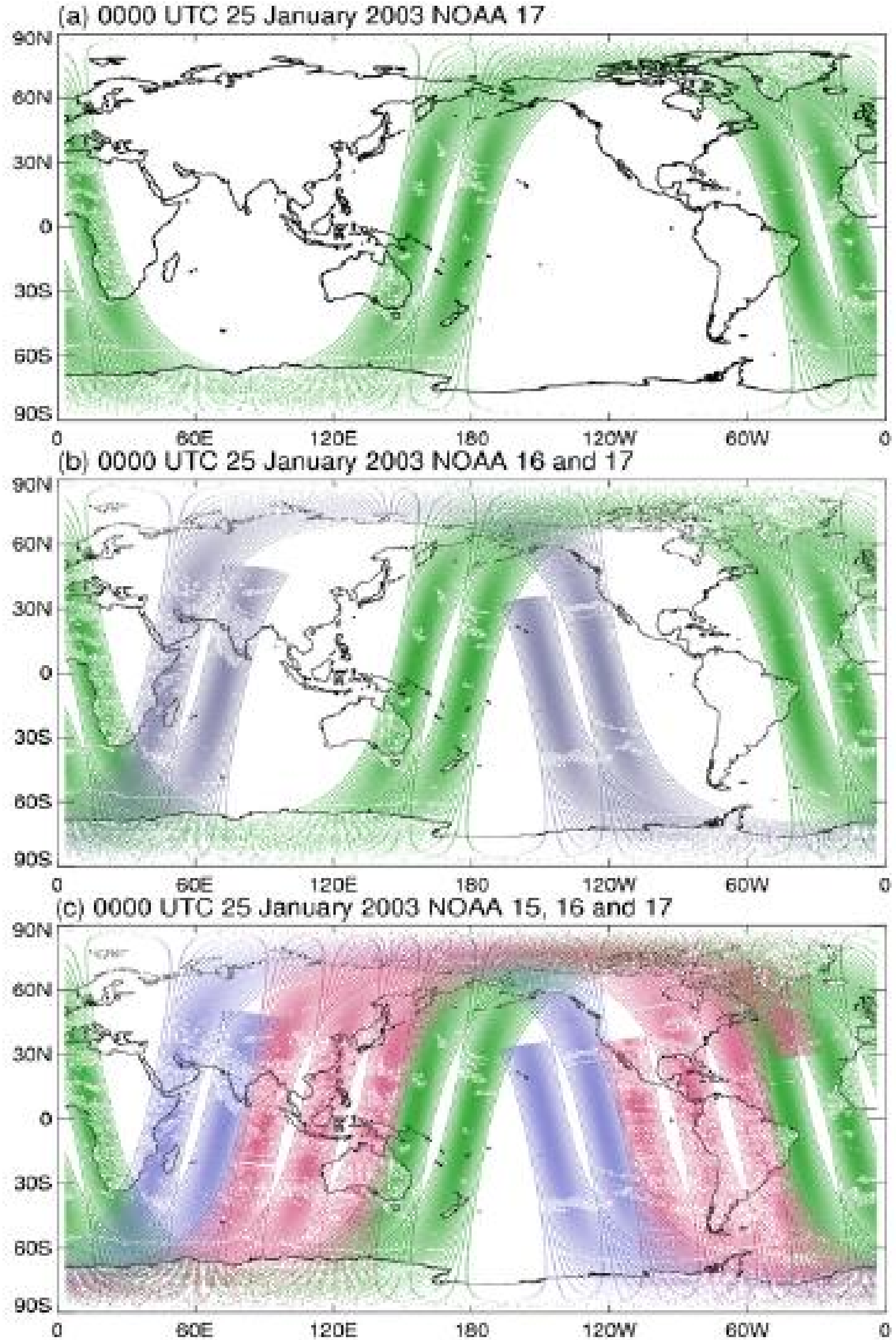
Fig. 10. Average track error (NM) by forecast hour for the control simulation and experiments where AMSU, HIRS, GEO winds and QuikSCAT were denied. The Atlantic Basin results are shown in (a), and the Eastern Pacific Basin results are shown in (b). A small sample size in the number of hurricanes precludes presenting the 96 hour results in the Eastern Pacific Ocean.

OBSERVING SYSTEM EXPERIMENTS

OBSERVING SYSTEM EXPERIMENT
WITH
NOAA POLAR ORBITING
SATELLITES

An Observing System Experiments (OSEs) during two seasons has been used to quantify the contributions made to forecast quality from the use of the National Oceanic and Atmospheric Administration's (NOAA) polar orbiting satellites.

The impact is measured by comparing the analysis and forecast results from an assimilation/forecast system using observations from one NOAA polar orbiting satellite, NOAA-17 (1_NOAA), with results from systems using observations from two, NOAA-16 and NOAA-17 (2_NOAA), and three, NOAA-15, 16 and 17 (3_NOAA), polar orbiting satellites.


(a) 0000 UTC 25 January 2003 NOAA 17
(b) 0000 UTC 25 January 2003 NOAA 16 and 17
(c) 0000 UTC 25 January 2003 NOAA 15, 16 and 17
90N
60N
30N
0
30S
60S
90S
0
60E
120E
180
120W
60W
0

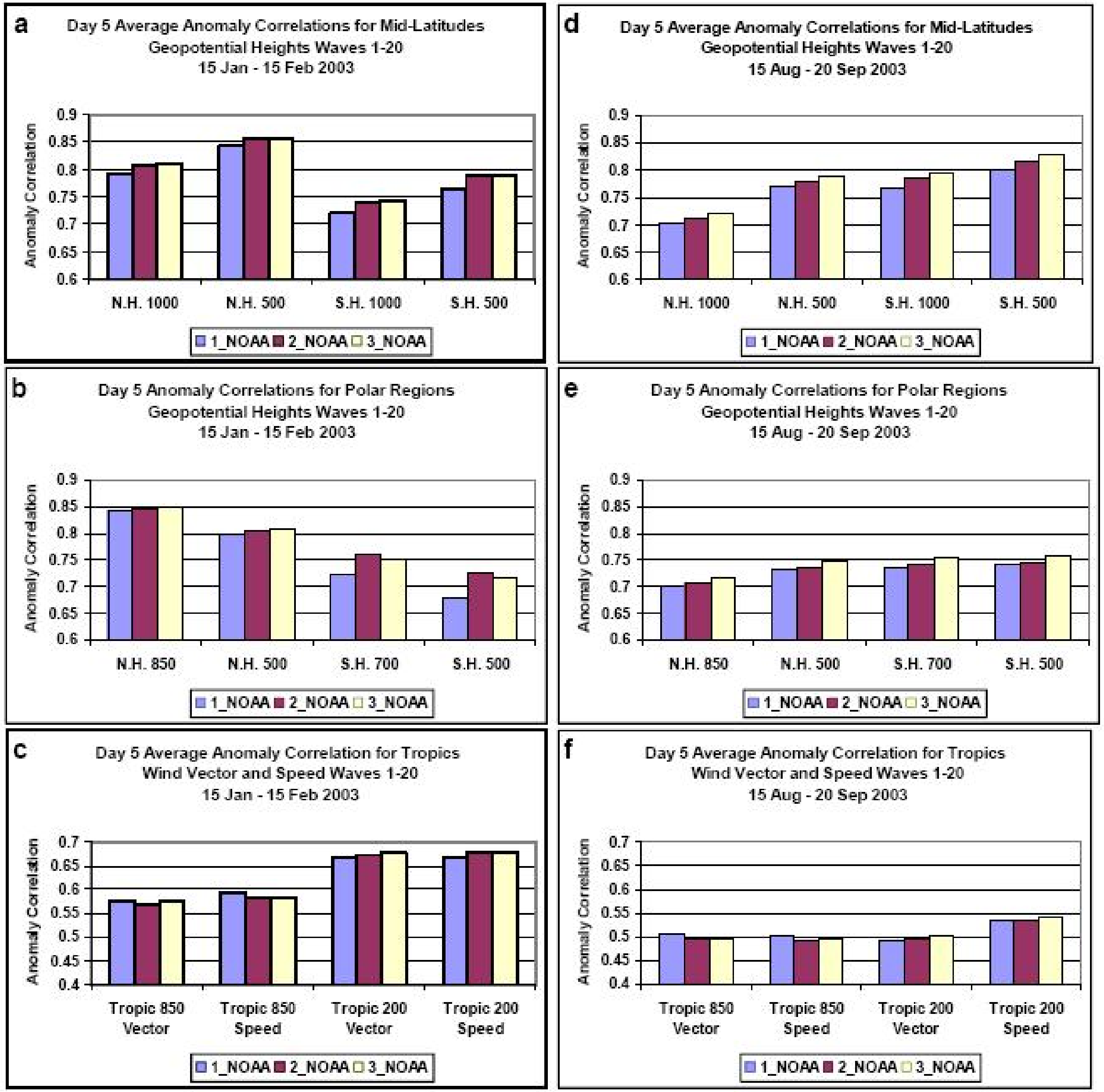


Fig. 12. The day 5 anomaly correlations for waves 1-20 for the (a and d) mid-latitudes, (b and e) polar regions and (c and f) tropics. Experiments include data from 3_NOAA, 2_NOAA, and 1_NOAA satellite(s). The 15 January to 15 February 2003 results are shown in the left column and the 15 August to 20 September 2003 results are shown in the right column. Note the different vertical scale in (c and f).

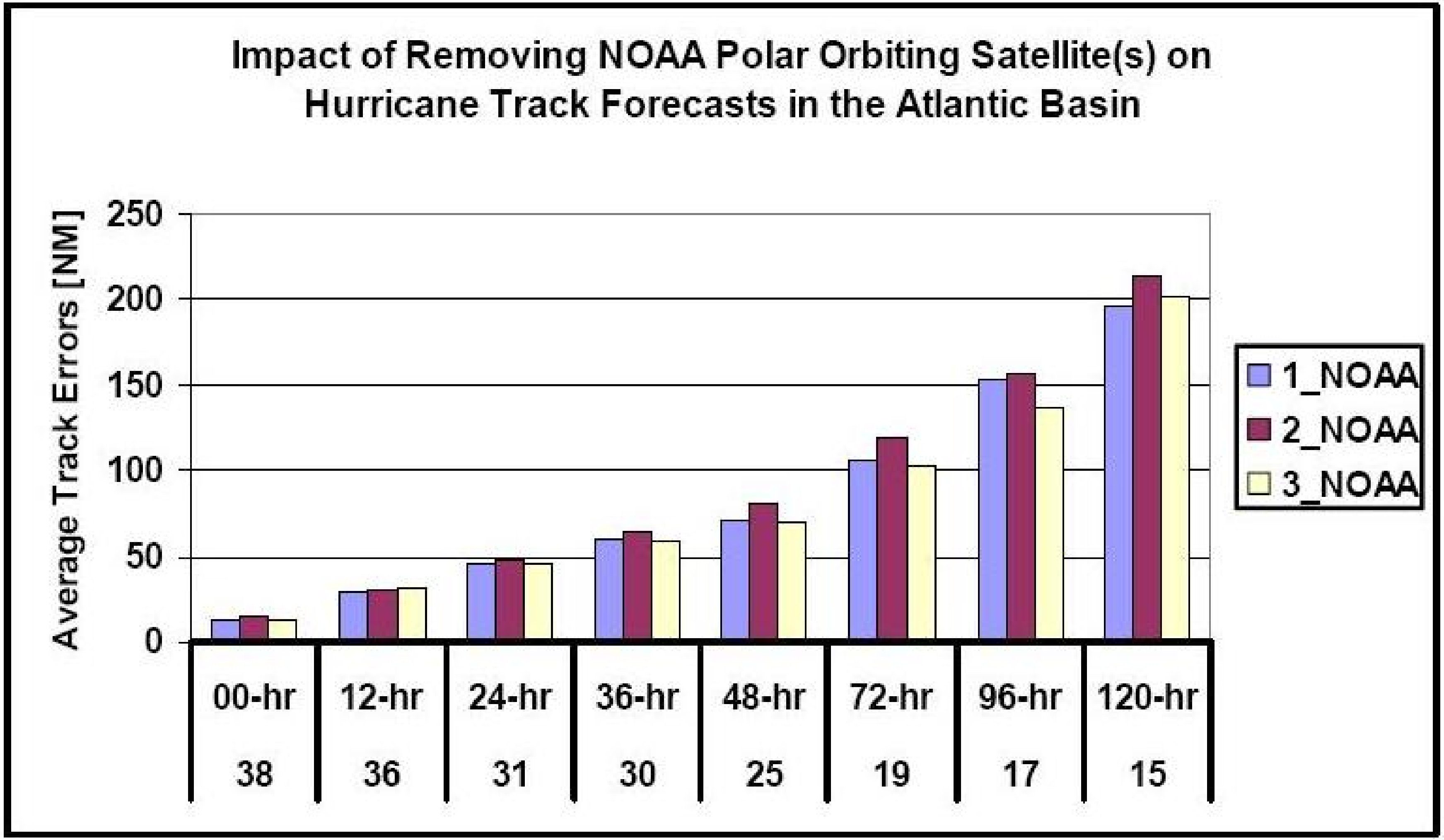


Fig. 13. Average track error (NM) by forecast hour for the 1_NOAA, 2_NOAA and 3_NOAA experiments in the Atlantic Basin during the period 15 August – 20 September 2003.

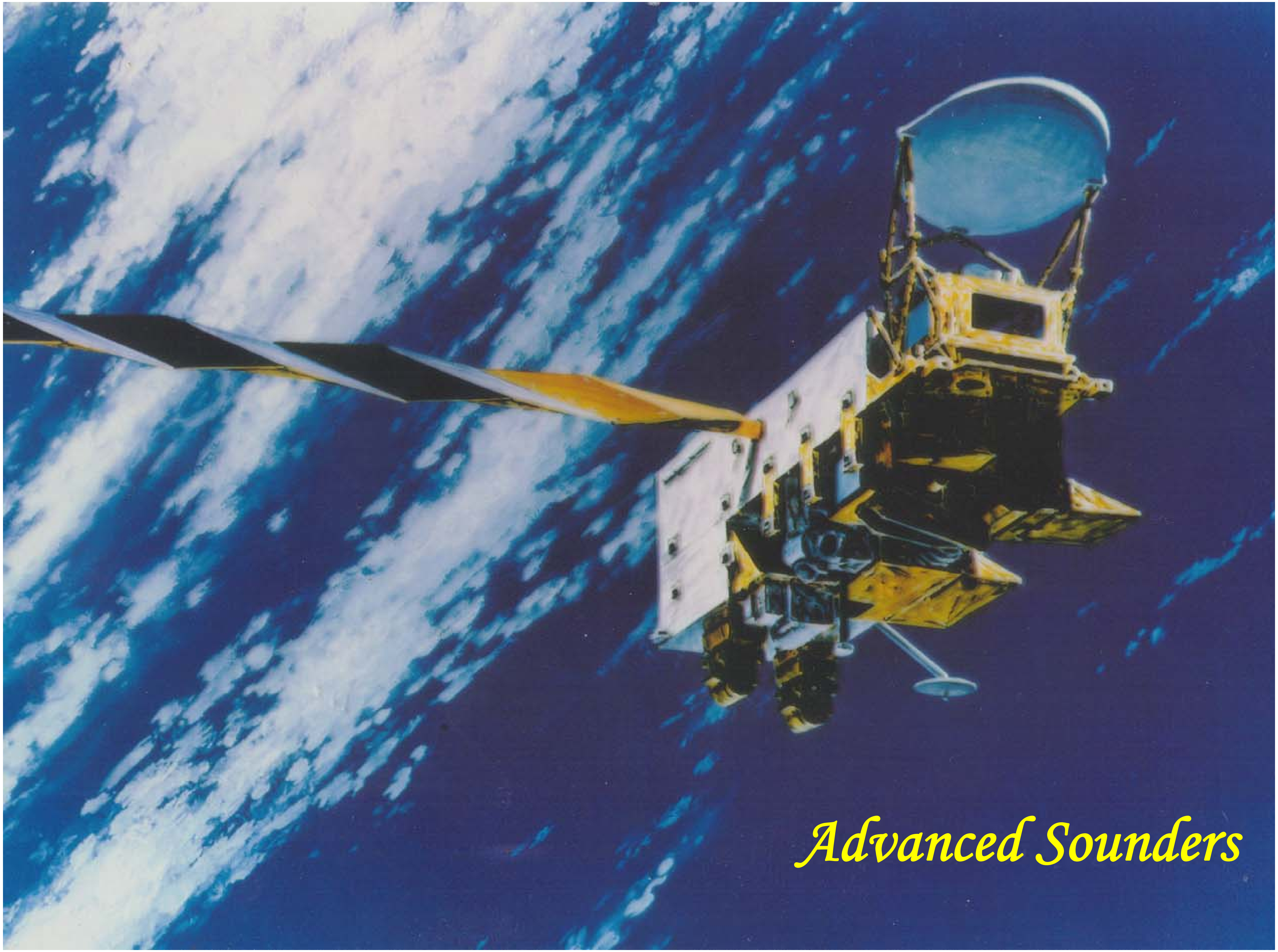
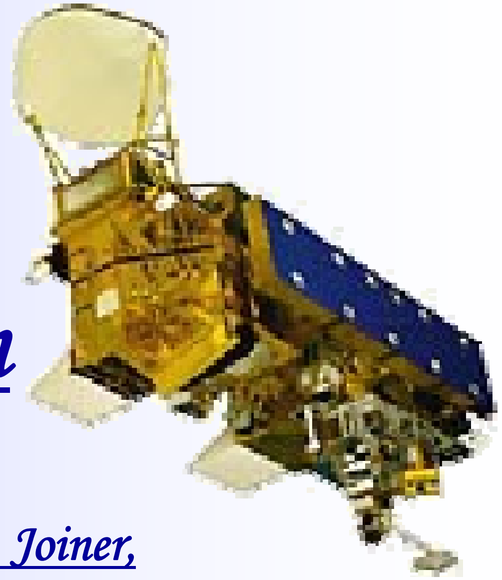

Advanced Sounders

Table 2.4-1 Characteristics of Advanced Infrared Sounders

Name	AIRS	IASI	CrIS	IRFS	GIFTS
Orbit	705 km	833 km	824 km	1000 km	Geostationary
Instrument type	Grating	FTS	FTS	FTS	FTS
Agency and Producer	NASA JPL/LoMIRIS	EUMETSAT/ CNES Alcatel	IPO (DoD/NOAA/ NASA) ITT	Russian Aviation and Space Agency	NASA/NOAA/ Navy. Space Dynamics Lab.
Spectral range (cm^{-1})	649 –1135 1217–1613 2169 –2674	Contiguous 645-2760	650 -1095 1210 –1750 2155 –2550	625 -2000 2200 -5000	685-1130 1650-2250
Unapodized spectral resolving power	1000 – 1400	2000 – 4000	900 – 1800	1200 - 4000	2000-6000
Field of view (km)	13 x 7	12	14	20	4
Sampling density per 50 km square	9	4	9	1	50
Power (W)	225	200	86	120	254
Mass (kg)	140	230	81	70	59
Platform	AQUA (EOS PM1)	METOP-1,-2,-3	NPP and NPOESS C1	METEOR 3MN2	Geostationary
Launch date	Feb 2002	2006	2009 for NPP 2013 NPOESS C1	2006+	2009?



AIRS Data Assimilation

J. Le Marshall, J. Jung, J. Derber, R. Treadon,
S.J. Lord, M. Goldberg, W. Wolf and H-S Liu, J. Joiner,
and J Woollen……

1 January 2004 – 31 January 2004

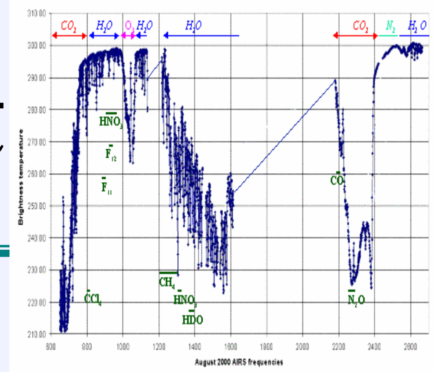
Used operational GFS system as Control

Used Operational GFS system Plus AIRS as Experimental System

Background

- Atmospheric Infrared Sounder (AIRS) was launched on the AQUA satellite on May 4, 2002 - Polar orbit 705 km, 13:30 ECT
- AIRS – high spectral resolution infrared sounder, demonstrated significantly improved accuracy of temperature and moisture soundings.
- NOAA/NESDIS is processing and distributing AIRS data and products in near real-time to operational NWP centers.

AIRS IR Instrument



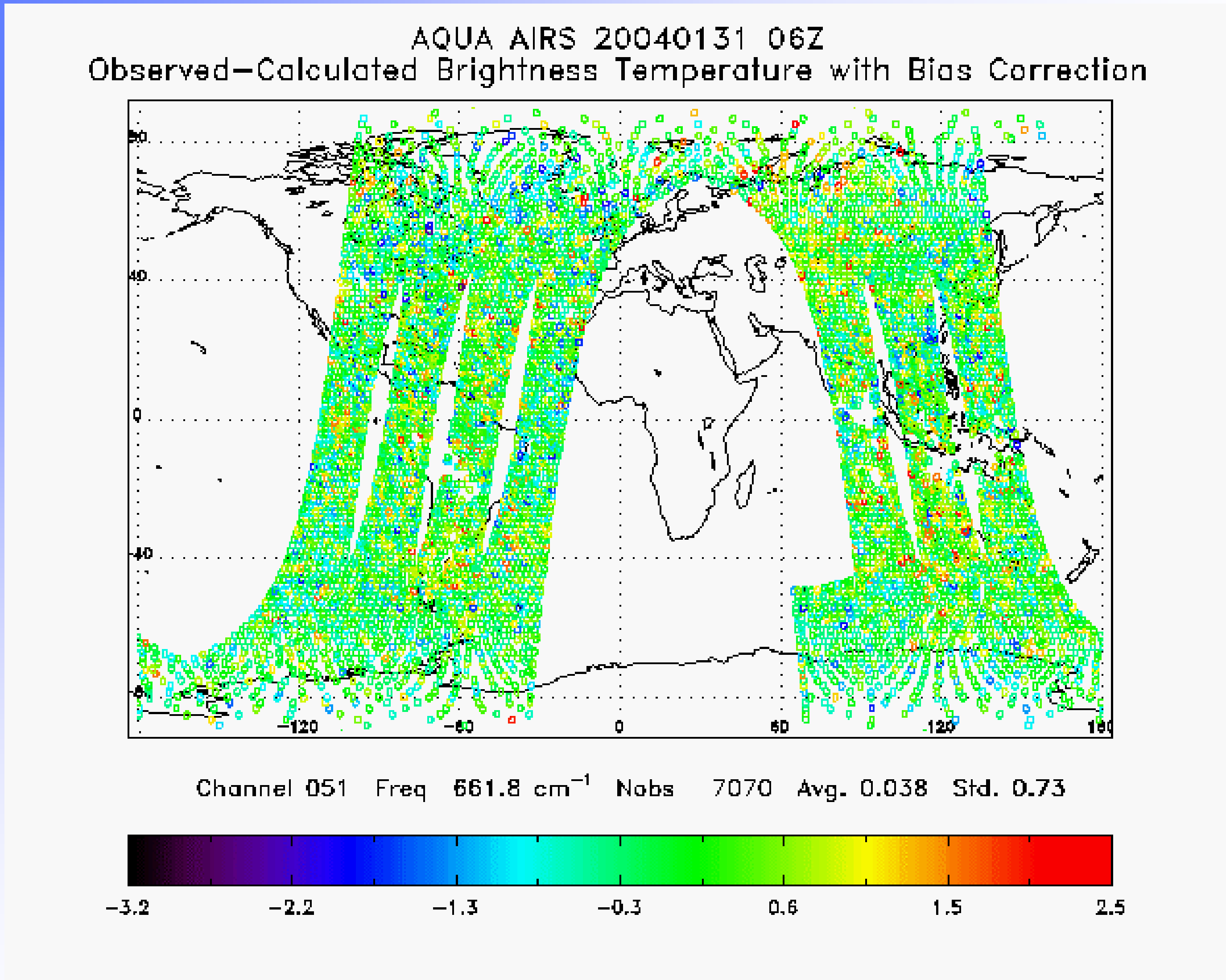
- AIRS is a cooled grating array spectrometer
- Spectral coverage 3.7 to 15.4 microns in 17 arrays with 2378 spectral channels (3.74-4.61 μm, 6.2-8.22 μm, 8.8-15.4 μm)
- Spectral resolution $\lambda/\Delta\lambda$=1200, 14 km FOV from 705km orbit
- Launch – May 2002
- Primary products: temperature profile (< 1 K accuracy), moisture profile (< 15%) , ozone (< 15 % (layers) and 3 % total)
- Research products: CO2, CO, CH4
- The integrated sounder system includes the AIRS VIS/NIR channels and microwave sounders

Table 1: Satellite data used operationally within the NCEP Global Forecast System

HIRS sounder radiances AMSU-A sounder radiances AMSU-B sounder radiances GOES sounder radiances GOES 9,10,12, Meteosat atmospheric motion vectors GOES precipitation rate SSM/I ocean surface wind speeds SSM/I precipitation rates	TRMM precipitation rates ERS-2 ocean surface wind vectors Quikscat ocean surface wind vectors AVHRR SST AVHRR vegetation fraction AVHRR surface type Multi-satellite snow cover Multi-satellite sea ice SBUV/2 ozone profile and total ozone

Global Forecast System Background

- Operational SSI (3DVAR) version used
- Operational GFS T254L64 with reductions in resolution at 84 (T170L42) and 180 (T126L28) hours. 2.5hr cut off



AIRS data coverage at 06 UTC on 31 January 2004. (Obs-Calc. Brightness Temperatures at 661.8 cm^{-1}are shown)

Table 2: AIRS Data Usage per Six Hourly Analysis Cycle

Data Category	Number of AIRS Channels
Total Data Input to Analysis Data Selected for Possible Use Data Used in 3D VAR Analysis(Clear Radiances)	$\sim 200 \times 10^6$ radiances (channels) $\sim 2.1 \times 10^6$ radiances (channels) $\sim 0.85 \times 10^6$ radiances (channels)

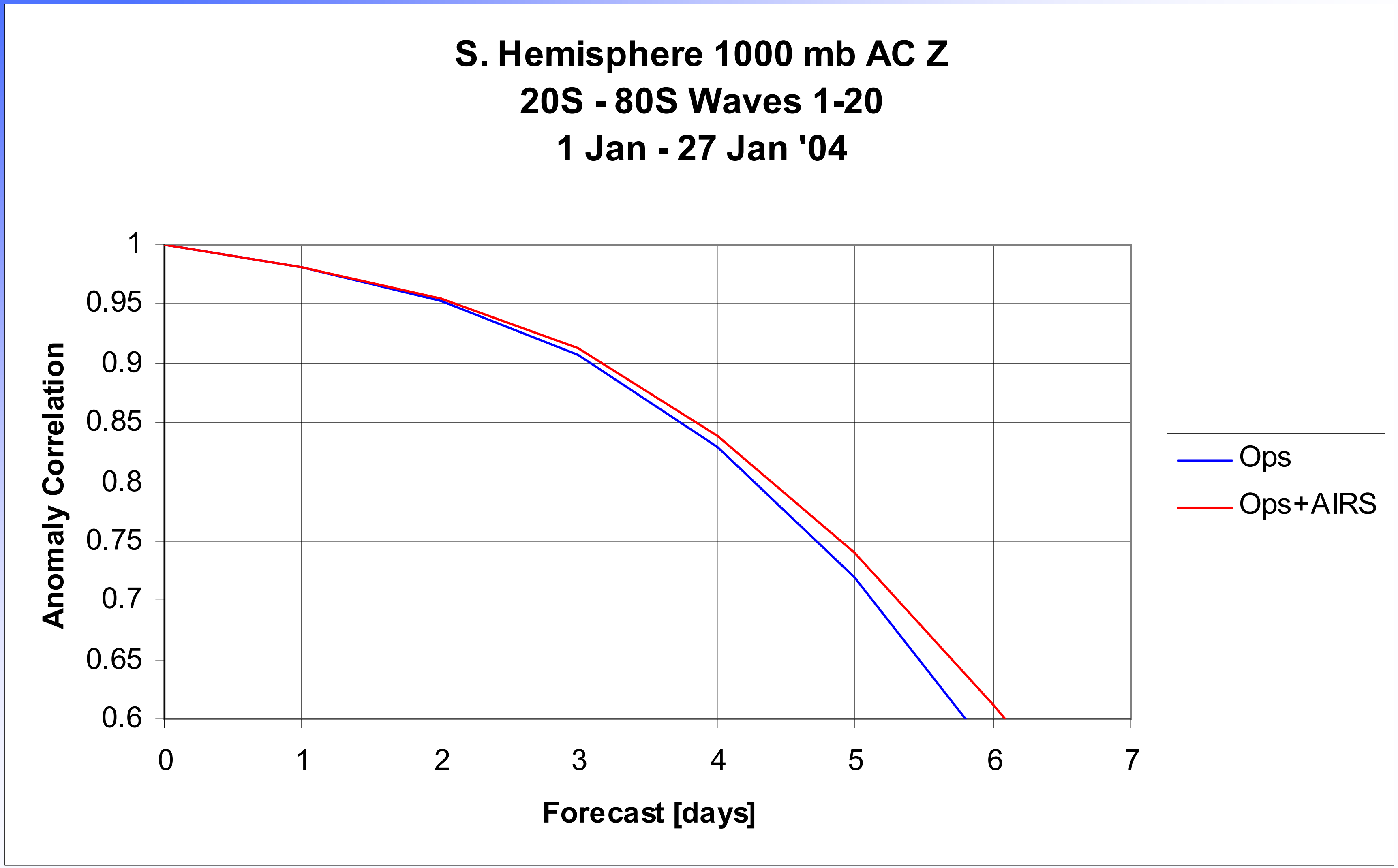


Figure1(a). 1000hPa Anomaly Correlations for the GFS with (Ops.+AIRS) and without (Ops.) AIRS data, Southern hemisphere, January 2004

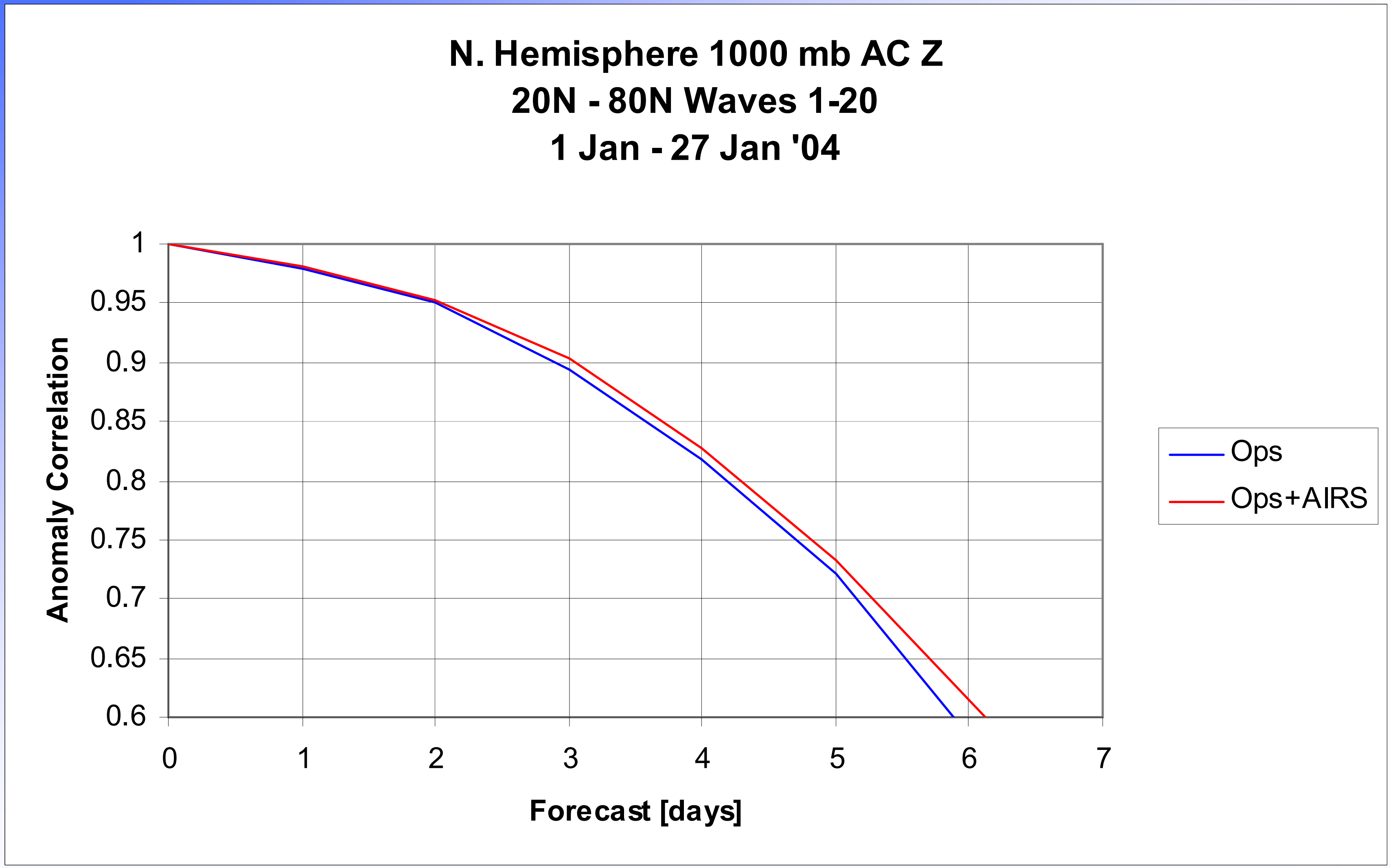


Figure3(a). 1000hPa Anomaly Correlations for the GFS with (Ops.+AIRS) and without (Ops.) AIRS data, Northern hemisphere, January 2004

AIRS Data Assimilation

J. Le Marshall, J. Jung, J. Derber, R. Treadon, S.J. Lord,
M. Goldberg, W. Wolf and H-S Liu, J. Joiner and J Woollen

January 2004

Used operational GFS system as Control

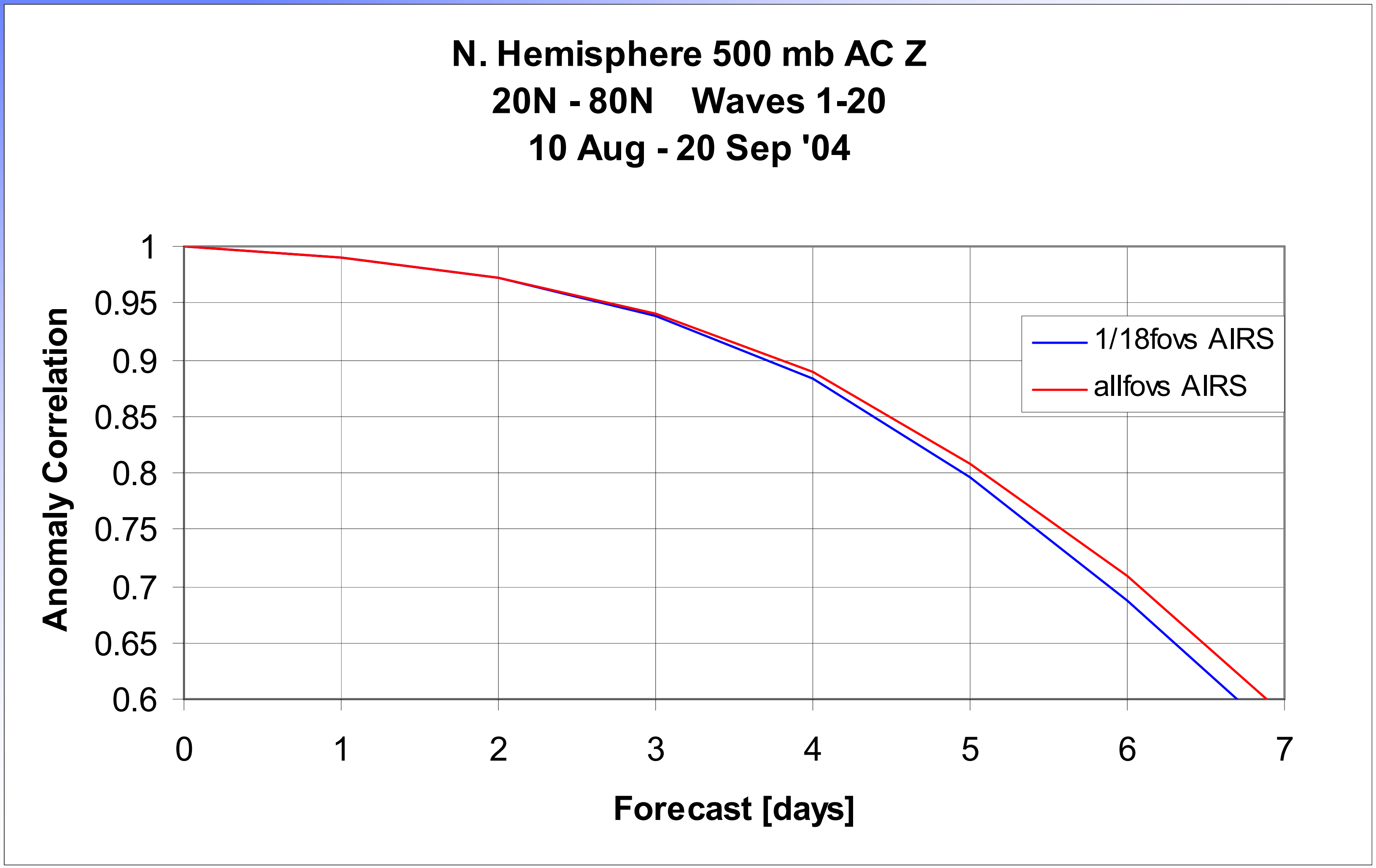
Used Operational GFS system Plus AIRS as Experimental System

Clear Positive Impact Both Hemispheres.Implemented -2005

AIRS Data Assimilation

Impact of Data density...

10 August – 20 September 2004

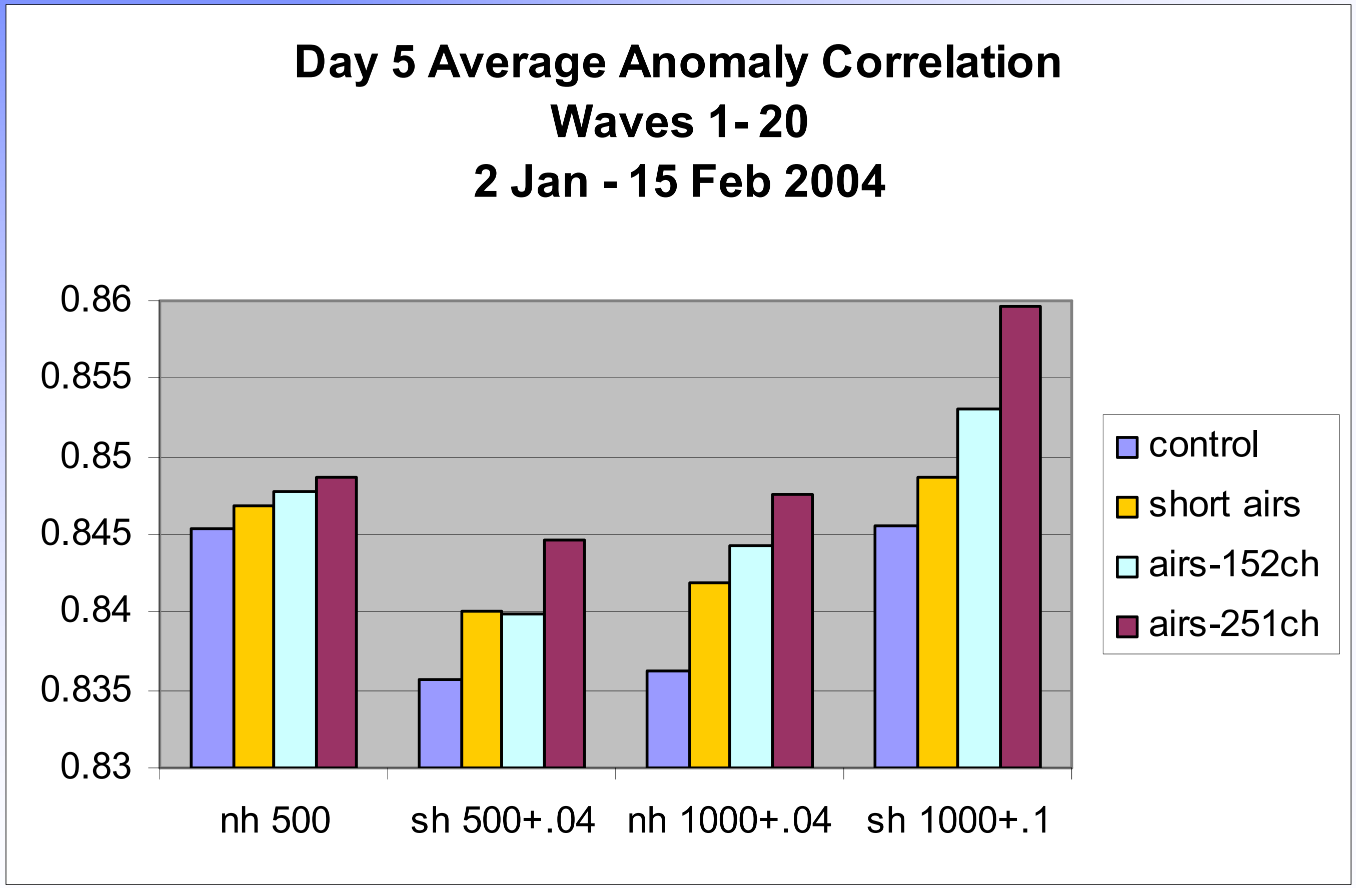


N. Hemisphere 500 mb AC Z
20N - 80N Waves 1-20
10 Aug - 20 Sep '04
Anomaly Correlation
1
0.95
0.9
0.85
0.8
0.75
0.7
0.65
0.6
0
1
2
3
4
5
6
7
Forecast [days]
1/18fovs AIRS
allfovs AIRS

AIRS Data Assimilation

Impact of Spectral coverage…

10 August – 20 September 2004


Day 5 Average Anomaly Correlation
Waves 1- 20
2 Jan - 15 Feb 2004
0.86
0.855
0.85
0.845
0.84
0.835
0.83
nh 500
sh 500+.04
nh 1000+.04
sh 1000+.1
control
short airs
airs-152ch
airs-251ch

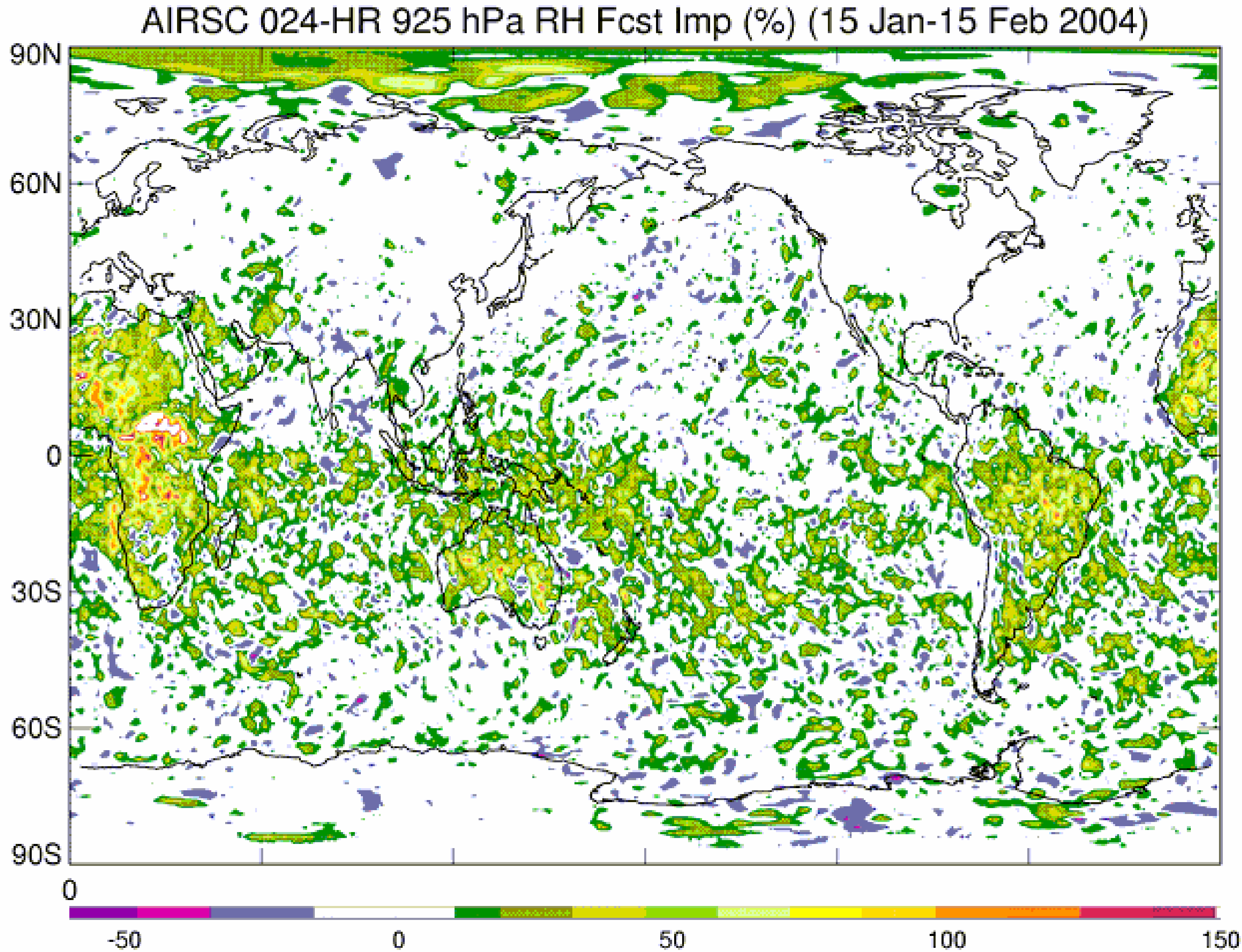
AIRS Data Assimilation

MOISTURE

Forecast Impact evaluates which forecast (with or without AIRS) is closer to the analysis valid at the same time.

Impact = 100* [Err(Cntl) – Err(AIRS)]/Err(Cntl)

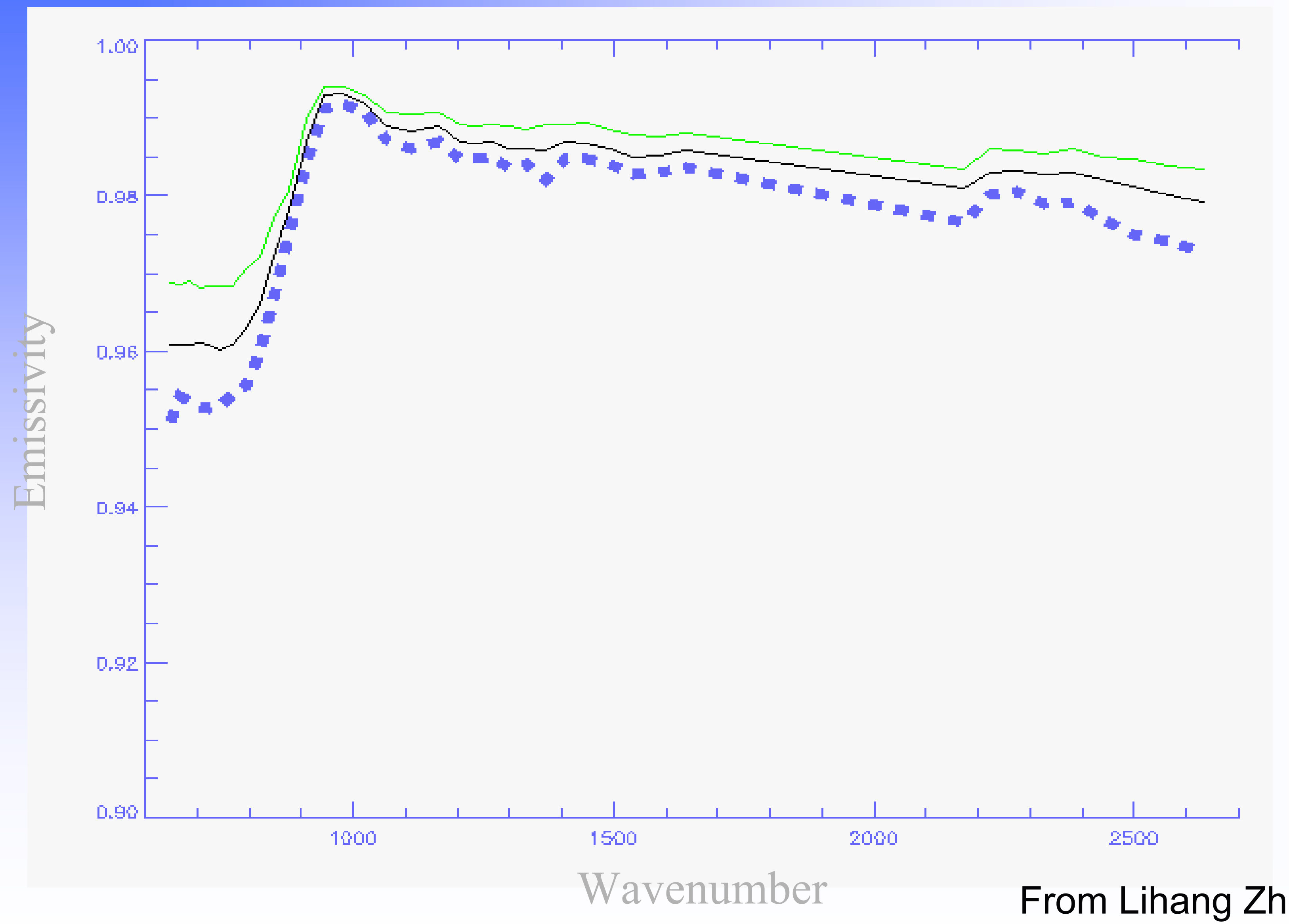
Where the first term on the right is the error in the Cntl forecast. The second term is the error in the AIRS forecast. Dividing by the error in the control forecast and multiplying by 100 normalizes the results and provides a percent improvement/degradation. A positive Forecast Impact means the forecast is better with AIRS included.


AIRSC 024-HR 925 hPa RH Fcst Imp (%) (15 Jan-15 Feb 2004)
90N
60N
30N
0
30S
60S
90S
0
-50
0
50
100
150

Surface Emissivity (ε) Estimation Methods

- Geographic Look Up Tables (LUTs) - CRTM
- Regression based on theoretical estimates
  - Lihang Zhou
- Minimum Variance, provides T_{surf} and ε *
- Eigenvector technique
  - Dan Zhou and Bill Smith
- Variational Minimisation – goal

Regression IR HYPERSPECTRAL EMISSIVITY - ICE and SNOW
Sample Max/Min Mean computed from synthetic radiance sample



From Lihang Zhou

Surface Emissivity (ε) Estimation Methods

JCSDA IR Sea Surface Emissivity Model (IRSSE)

Initial NCEP IRSSE Model based on Masuda et al. (1998)

Updated to calculate Sea Surface Emissivities via Wu and Smith (1997)

Van Delst and Wu (2000)

Includes high spectral resolution (for instruments such as AIRS)

Includes sea surface reflection for larger angles

JCSDA Infrared Sea Surface Emissivity Model – Paul Van Delst
Proceedings of the 13th International TOVS Study Conference
Ste. Adele, Canada, 29 October - 4 November 2003

AIRS SST Determination

Use AIRS bias corrected radiances from GSI

AIRS channels used are :
119 – 129 (11)
154 – 167 (14)
263 – 281 (19)

Method is the minimum (emissivity) variance technique

Channels used in Pairs : 119, 120; 120, 121; 121, 122; . . etc

For a downward looking infrared sensor:

$$I_\nu = \int_0^Z B_\nu[T(z)] \frac{\partial \tau_\nu(z,Z)}{\partial z} dz + \varepsilon_\nu \bullet B_\nu(T_S) \bullet \tau_\nu(0,Z) +$$

$$(1-\varepsilon_\nu) \bullet \tau_\nu(0,Z) \int_\infty^0 B_\nu[T(z)] \frac{\partial \tau_\nu(z,Z)}{\partial z} dz$$

where I_ν, ε_ν, B_ν, T_S, $\tau_\nu(z_1, z_2)$, Z and $T(z)$ are observed spectral radiance, spectral emissivity, spectral Planck function, the surface temperature, spectral transmittance at wavenumber ν from altitude z_1 to z_2, sensor altitude z, and air temperature at altitutide z respectively.

The solution can be written as :

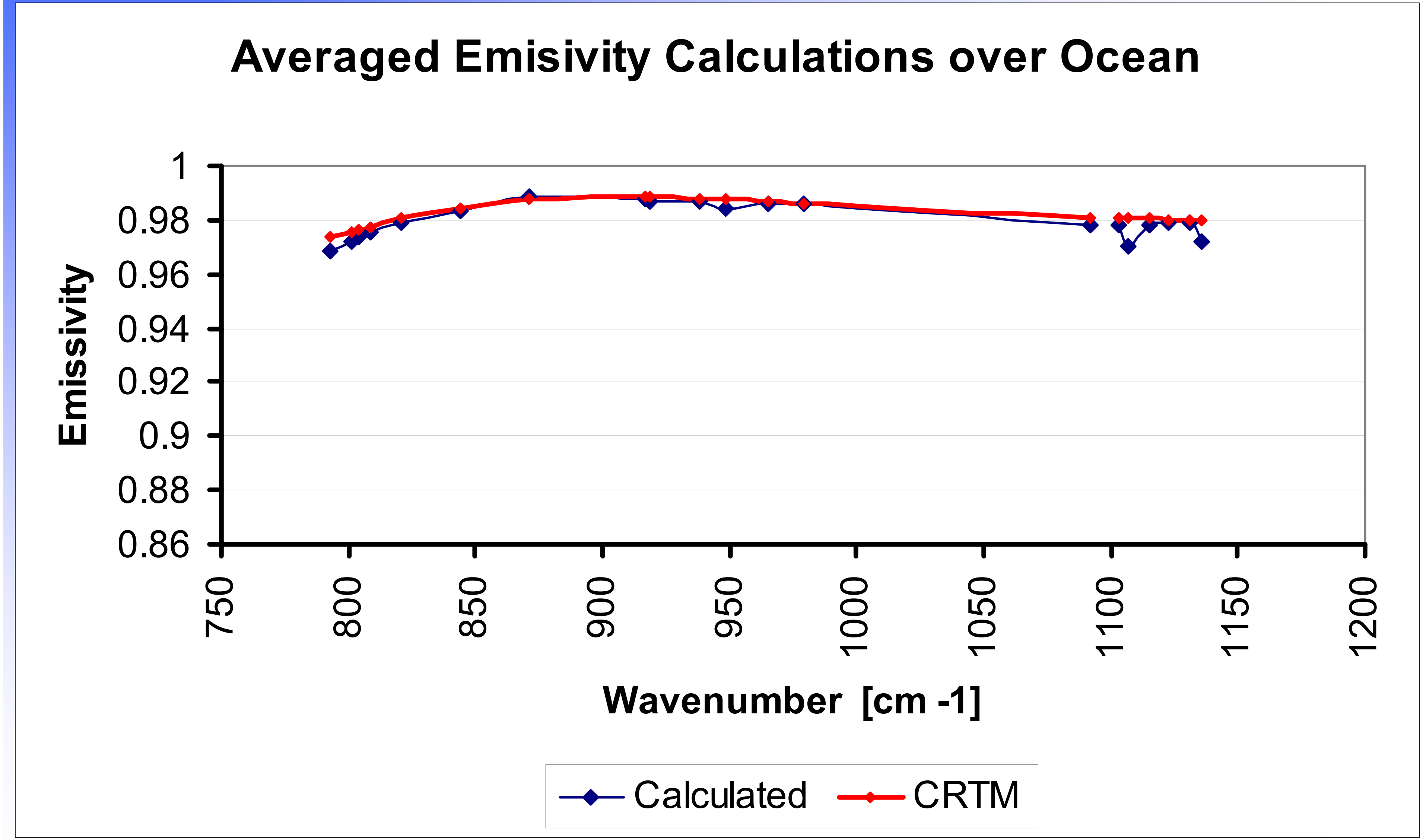
$$\hat{\varepsilon}_{\nu} = \frac{\left[R_{\nu}^{OBS} - N_{\nu}^{\uparrow}\right] - \tau_{\nu}\overline{N_{\nu}^{\downarrow}}}{\tau_{\nu}B_{\nu}\left(\hat{T}_{S}\right) - \tau_{\nu}\overline{N_{\nu}^{\downarrow}}}$$

Where R^{OBS} is the observed upwelling radiance, N↑ represents the upwelling emission from the atmosphere only and N↓ represents the downwelling flux at the surface. The ^ symbol denotes the "effective" quantities as defined in Knuteson et al. (2003).

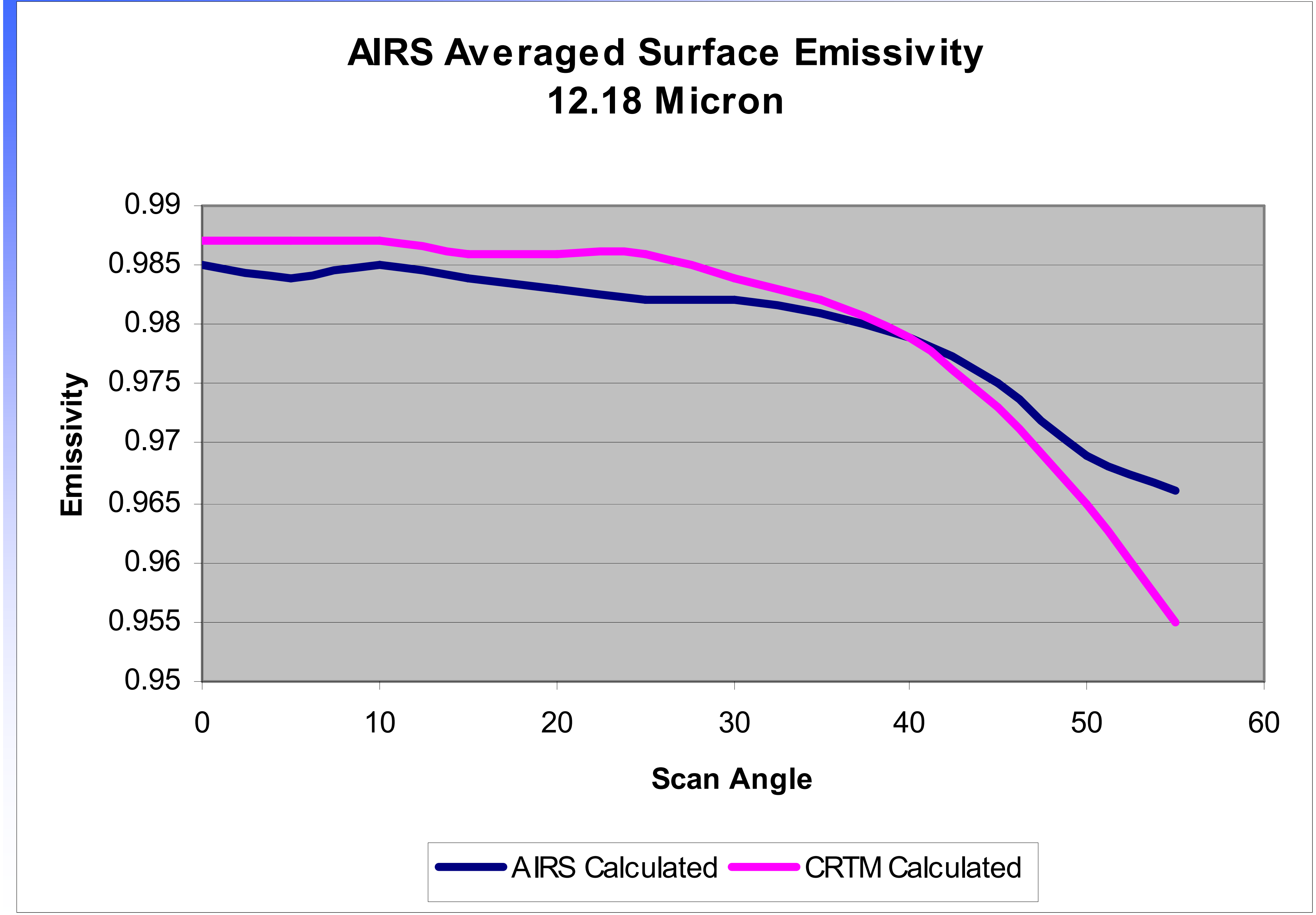
The SST is the T_S that minimises :

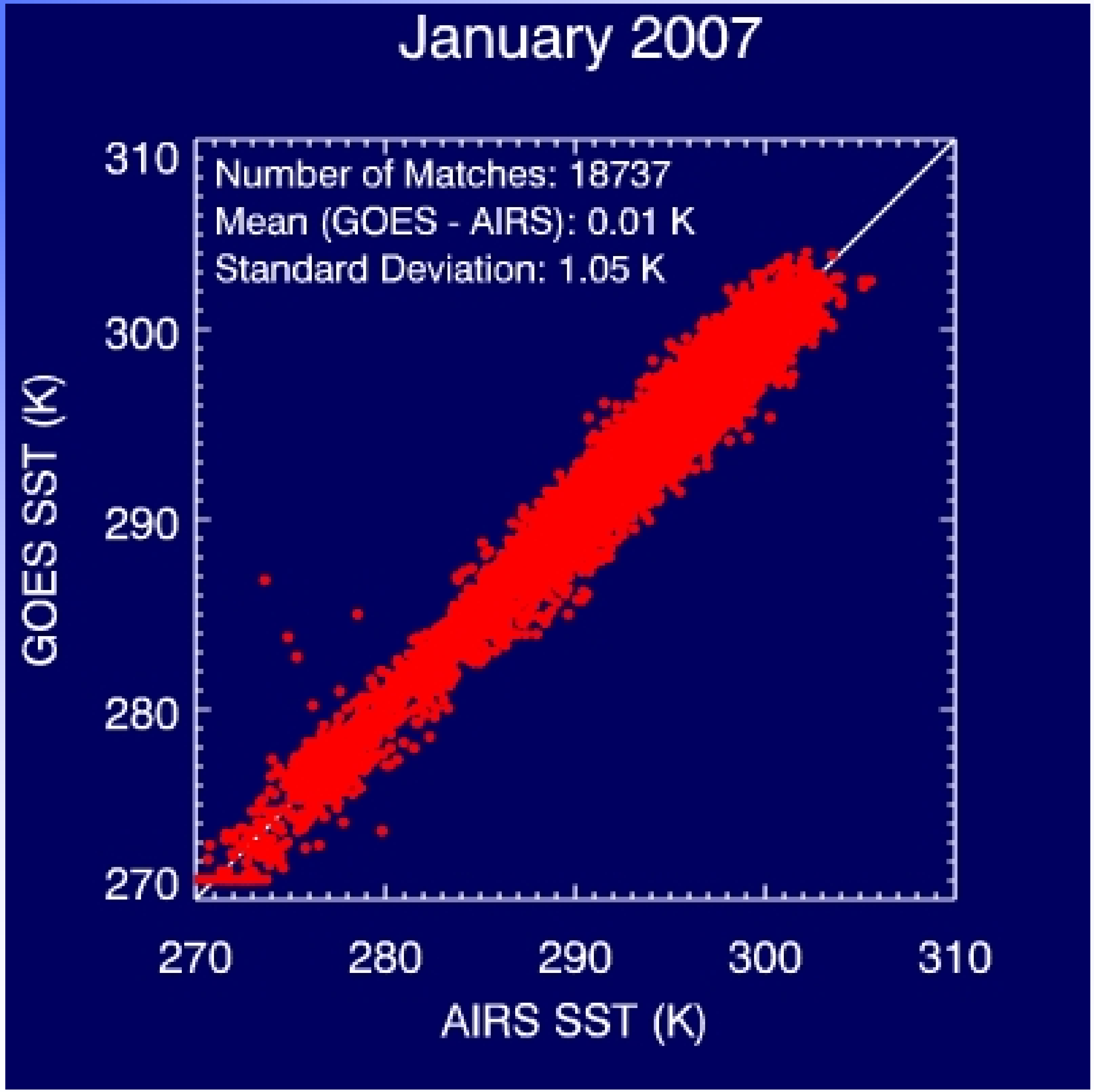
$$\sum \left(\varepsilon_{i} - \varepsilon_{i+1}\right)^{2}$$

Minimum Variance IR HYPERSPECTRAL EMISSIVITY - Water

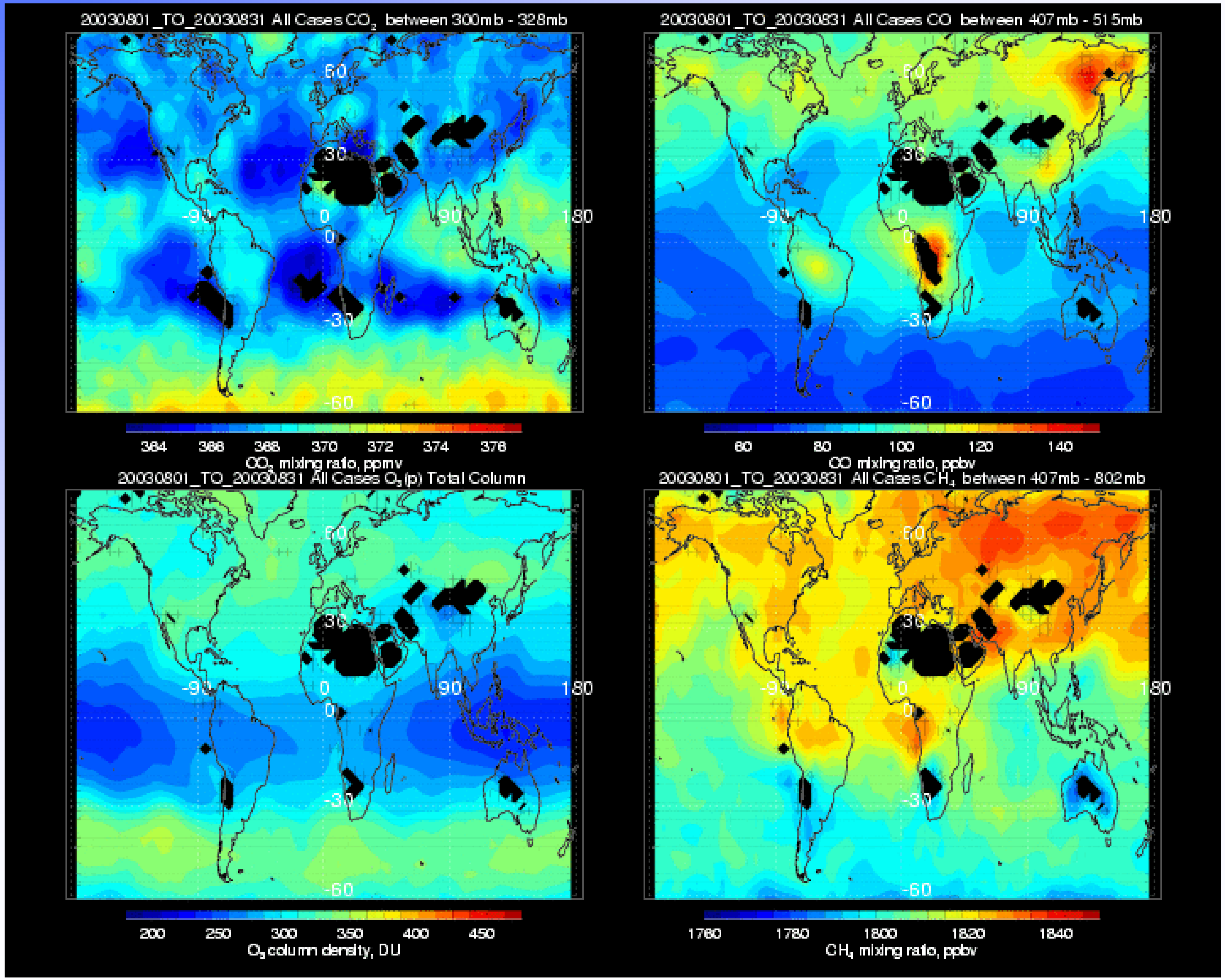


Minimum Variance IR HYPERSPECTRAL EMISSIVITY - Water




January 2007
Number of Matches: 18737
Mean (GOES - AIRS): 0.01 K
Standard Deviation: 1.05 K
310
300
290
280
270
GOES SST (K)
270
280
290
300
310
AIRS SST (K)

Preliminary Trace Gas Maps (Maddy & Barnet)



MODIS Wind Assimilation into the NCEP Global Forecast System

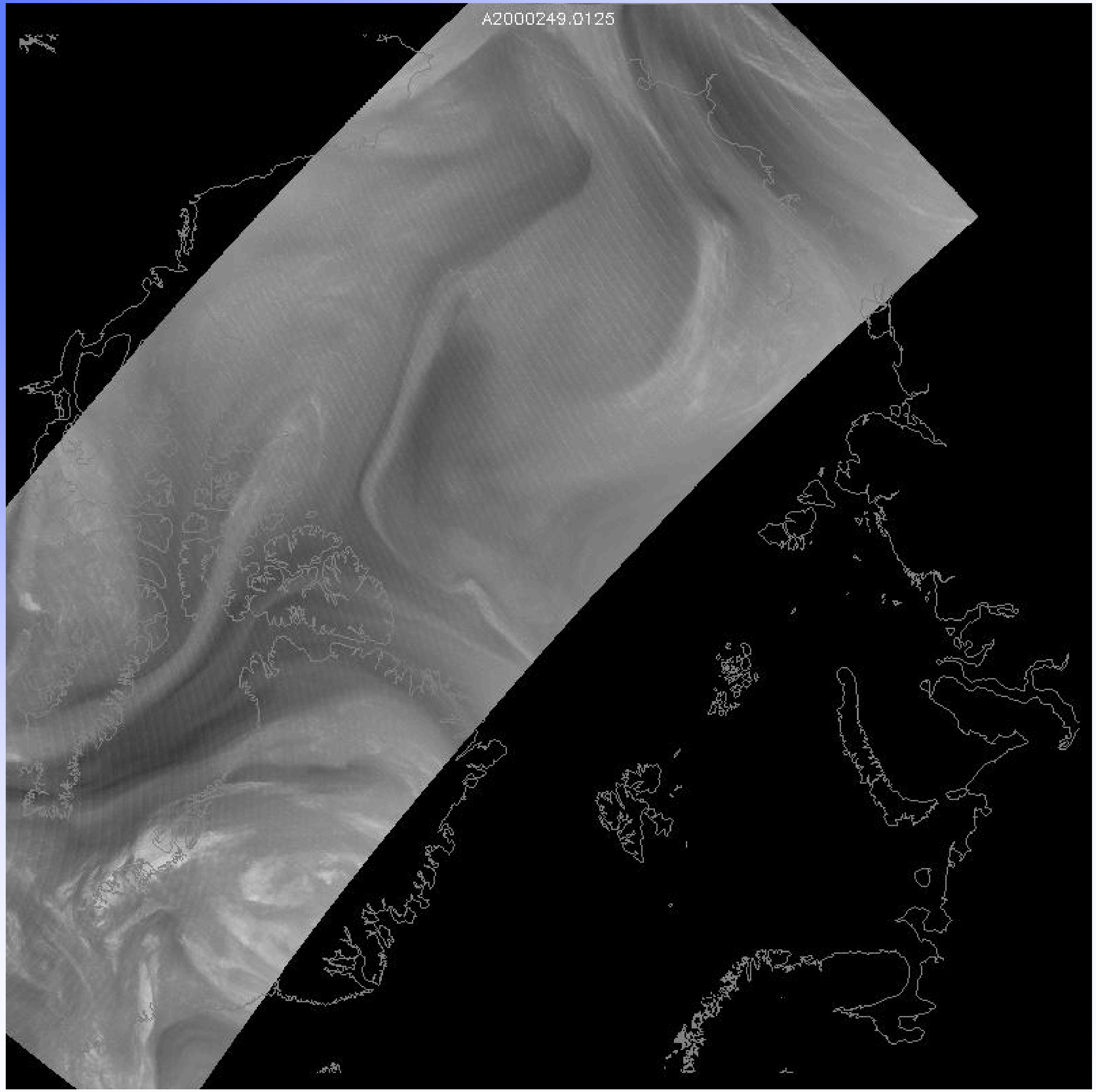
AMV

ESTIMATION

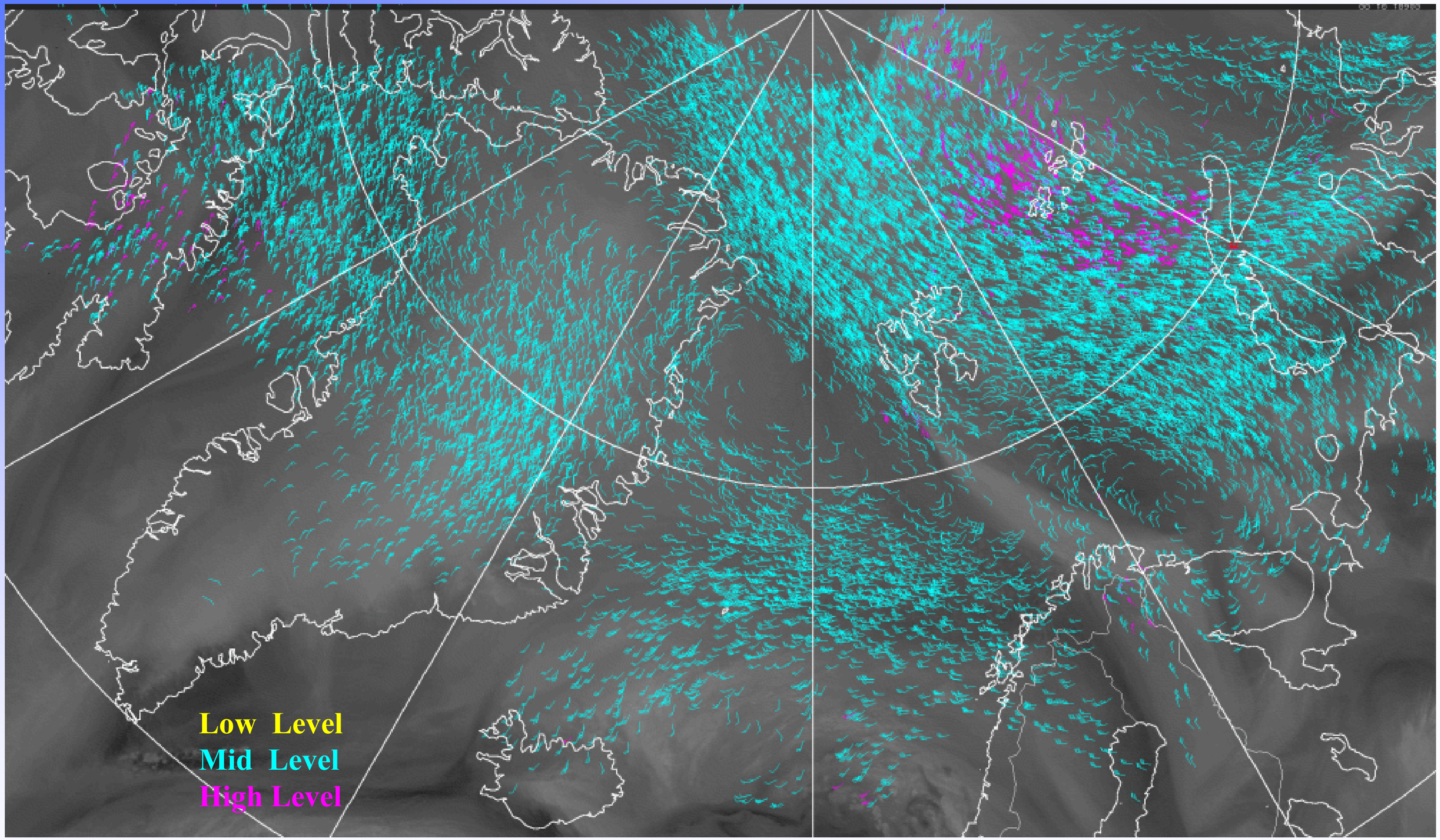
11µm and 6.7 µm gradient features tracked

Tracers selected in middle image

Histogram, H_2O intercept method, forecast model and auto editor used for height assignment



Water Vapor Winds



05 March 2001: Daily composite of 6.7 micron MODIS data over half of the Arctic region. Winds were derived over a period of 12 hours. There are about 13,000 vectors in the image. Vector colors indicate pressure level - yellow: below 700 hPa, cyan: 400-700 hPa, purple: above 400 hPa.

Global Forecast System Background

- Operational SSI (3DVAR) version used
- Operational GFS T254L64 with reductions in resolution at 84 (T170L42) and 180 (T126L28) hours. 2.5hr cut off

The Trial

- Winds assimilated only in second last analysis (later "final" analysis) to simulate realistic data availability.

Table 1: Satellite data used operationally within the GMAO/NCEP Global Forecast System

HIRS sounder radiances AMSU-A sounder radiances AMSU-B sounder radiances GOES sounder radiances GOES 9,10,12, Meteosat atmospheric motion vectors GOES precipitation rate SSM/I ocean surface wind speeds SSM/I precipitation rates	TRMM precipitation rates ERS-2 ocean surface wind vectors Quikscat ocean surface wind vectors AVHRR SST AVHRR vegetation fraction AVHRR surface type Multi-satellite snow cover Multi-satellite sea ice SBUV/2 ozone profile and total ozone

Table 1: Comparison of radiosonde wind estimates with Terra and Aqua based MODIS AMVs, colocated within 150km over high latitudes for the period 5 May 2005 to 10 January 2006 inclusive, where the AMV QI $\geq$ 0.85. [IR = 11µm based winds, WV = 6.7 µm based winds and MMVD = mean magnitude of vector difference (ms^{-1})].

Type		AQUA IR	AQUA WV	TERRA IR	TERRA WV
Low 999-700hPa	No. of Obs.	142	N/A	80	N/A
	MMVD (ms^{-1})	3.92	N/A	3.58	N/A
	RMS Vec. Diff. (ms^{-1})	4.57	N/A	4.02	N/A
	Speed Bias (ms^{-1})	-0.30	N/A	-0.03	N/A
Middle 699-400HPa	No. of Obs.	342	558	287	485
	MMVD (ms^{-1})	4.38	4.34	4.20	4.30
	RMS Vec. Diff. (ms^{-1})	4.93	4.90	4.79	4.85
	Speed Bias (ms^{-1})	-1.01	-0.72	-0.35	-0.24
High 399-150hPa	No. of Obs.	106	358	76	345
	MMVD (ms^{-1})	4.71	4.96	4.81	4.28
	RMS Vec. Diff. (ms^{-1})	5.22	5.55	5.26	4.83
	Speed Bias (ms^{-1})	-0.80	-0.65	-0.50	-0.34

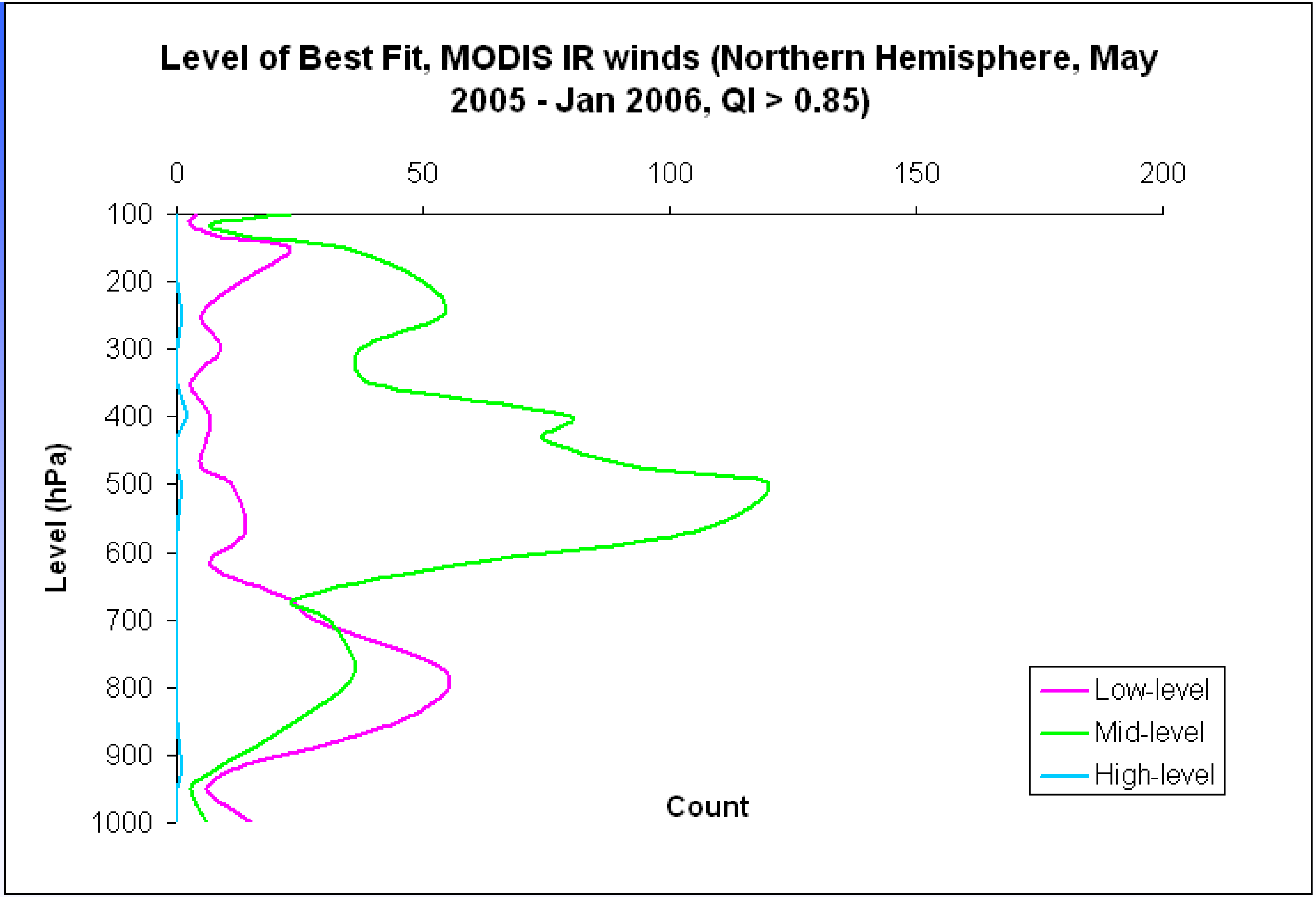


Fig 1 (a) Distribution of levels of best fit compared to a collocated radiosonde profile for AMVs with pressure altitudes in the ranges 500 ± 50 hPa (Mid-level), 300 ± 50 hPa (High level) and , 850 ± 50 hPa (Low level). In all cases, the AMV QI is in the range 0.85 to 1.0.

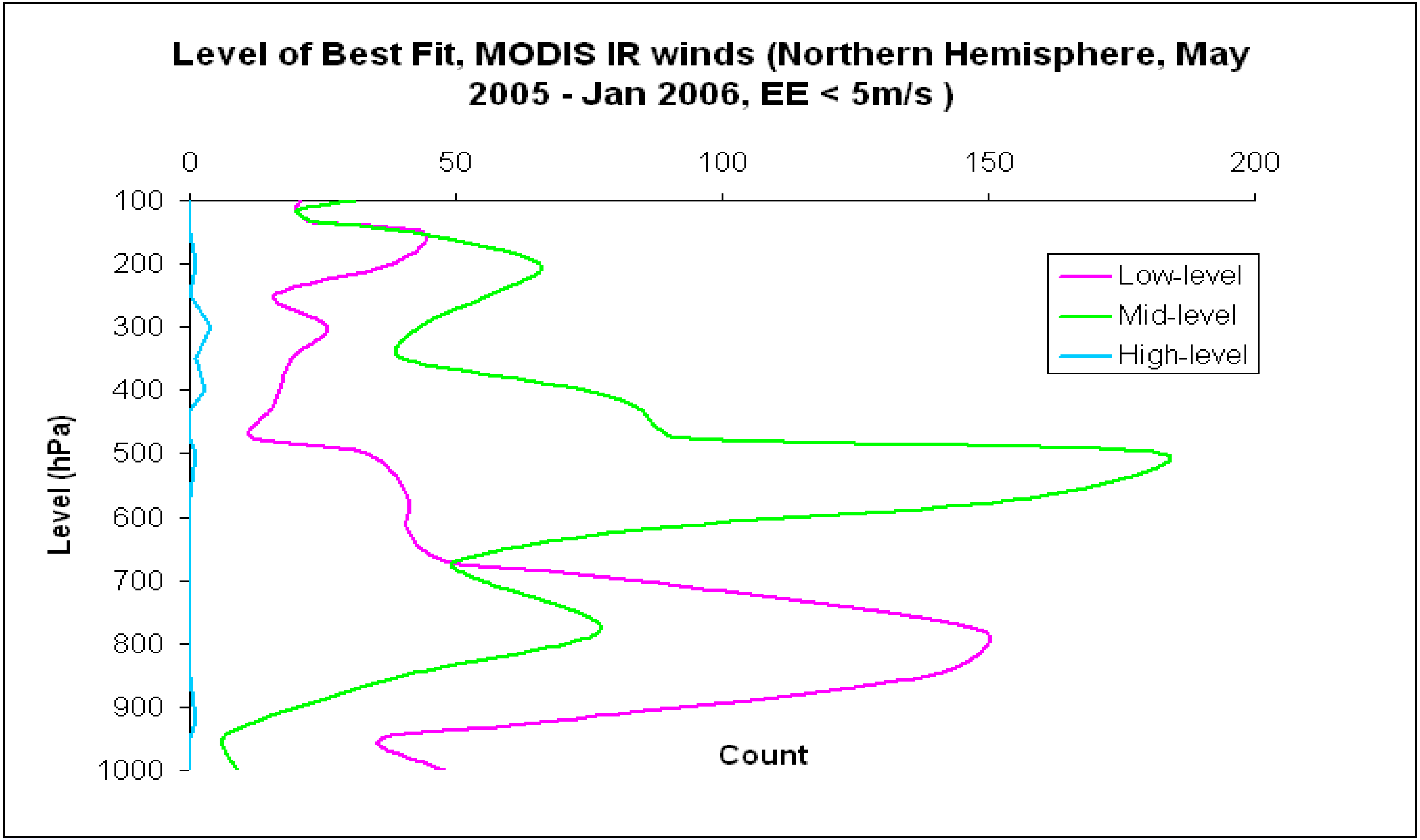


Fig 1 (b) Distribution of levels of best fit compared to a collocated radiosonde profile for AMVs with pressure altitudes in the ranges 500 ± 50 hPa (mid-level), 300 ± 50 hPa (high level) and , 850 ± 50 hPa (low level). In all cases, the AMV EE is less than 5 m/s.

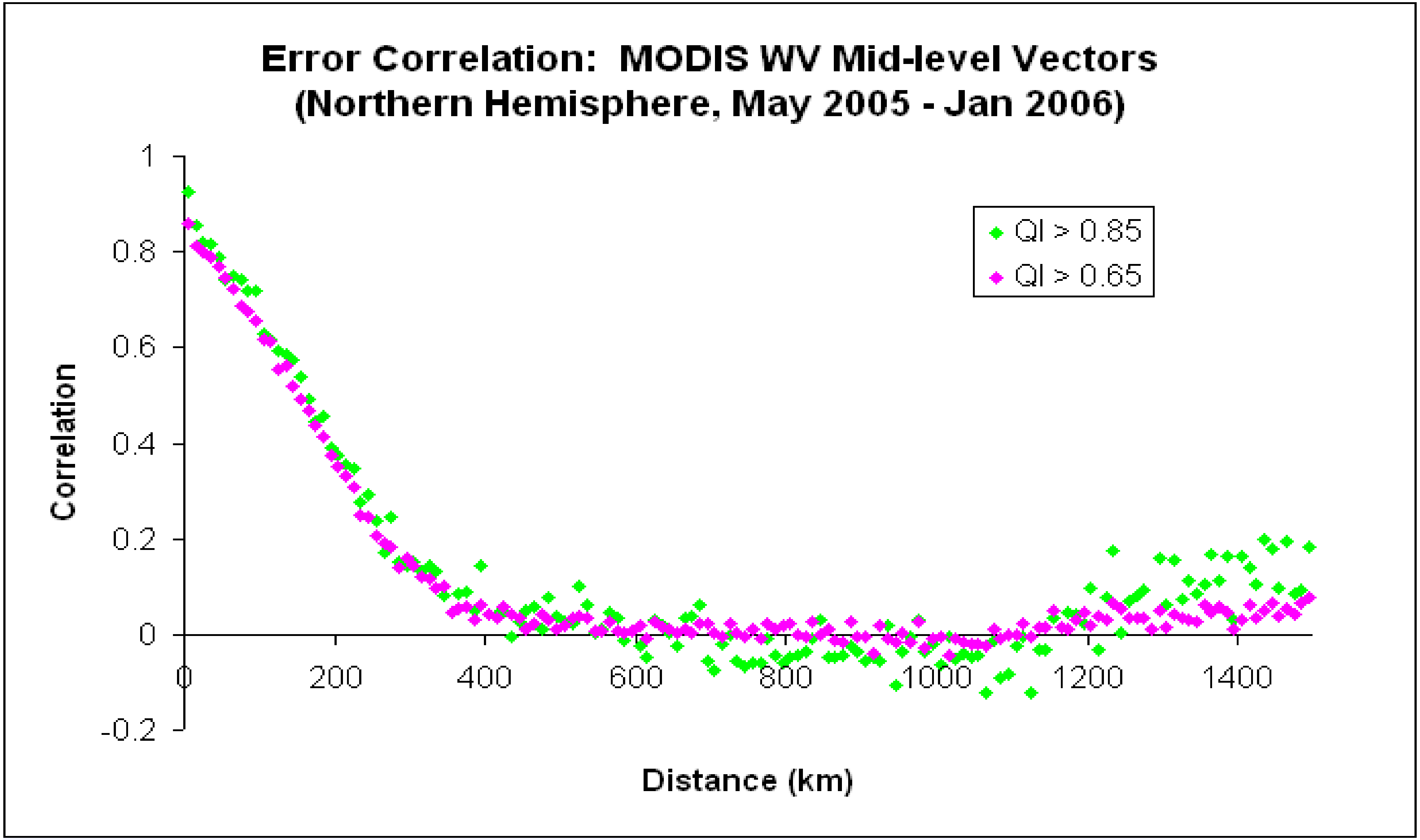


Fig. 2 (a) Error Correlation versus distance (using 10 km bins), computed using radiosonde winds, for MODIS WV Mid-level Vectors (Northern Hemisphere, May 2005 – Jan 2006)

Type	R_{00}	R_0	L (km)	Corr. Err. (ms^{-1})	RMSD (ms^{-1})
Low IR	-0.029	0.68	128.9	3.01	4.51
Mid IR	-0.010	0.82	113.1	4.16	5.07
High IR	0.029	0.78	117.7	4.28	5.49
Mid WV	0.010	0.85	95.3	4.29	5.05
High WV	-0.051	0.91	107.6	4.83	5.31

Table 2 (a) Parameters of the SOAR function (Equation 1) which best model the measured error correlations for the MODIS AMV types listed in the left column of the table. (QI = 0.65 to 1)

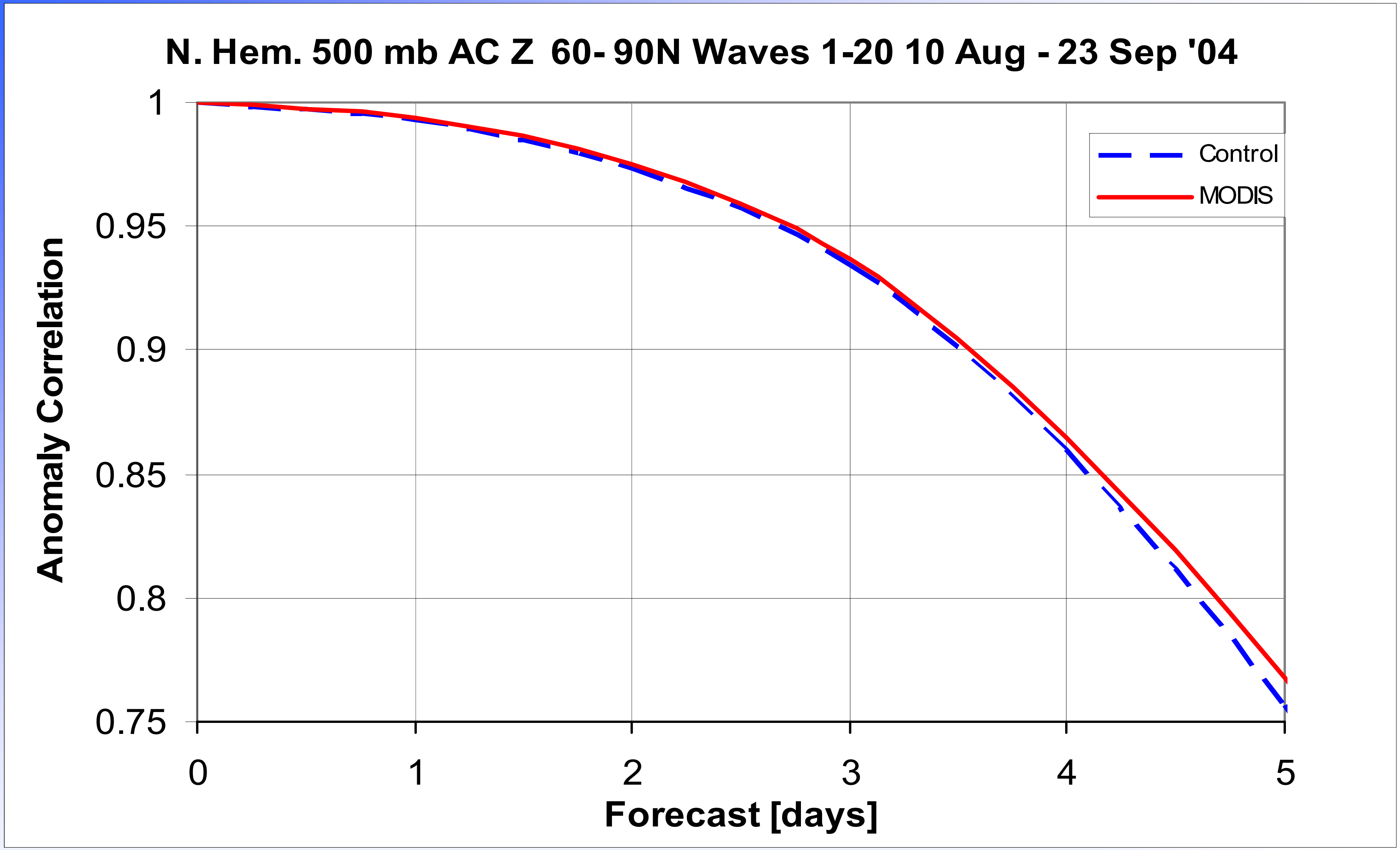


Fig. 3. The 500 hPa geopotential height Anomaly Correlation for the Northern Hemisphere (60° N – 90° N), for the GFS control and the GFS control including MODIS AMVs, for the period 10 August to 23 September 2004.

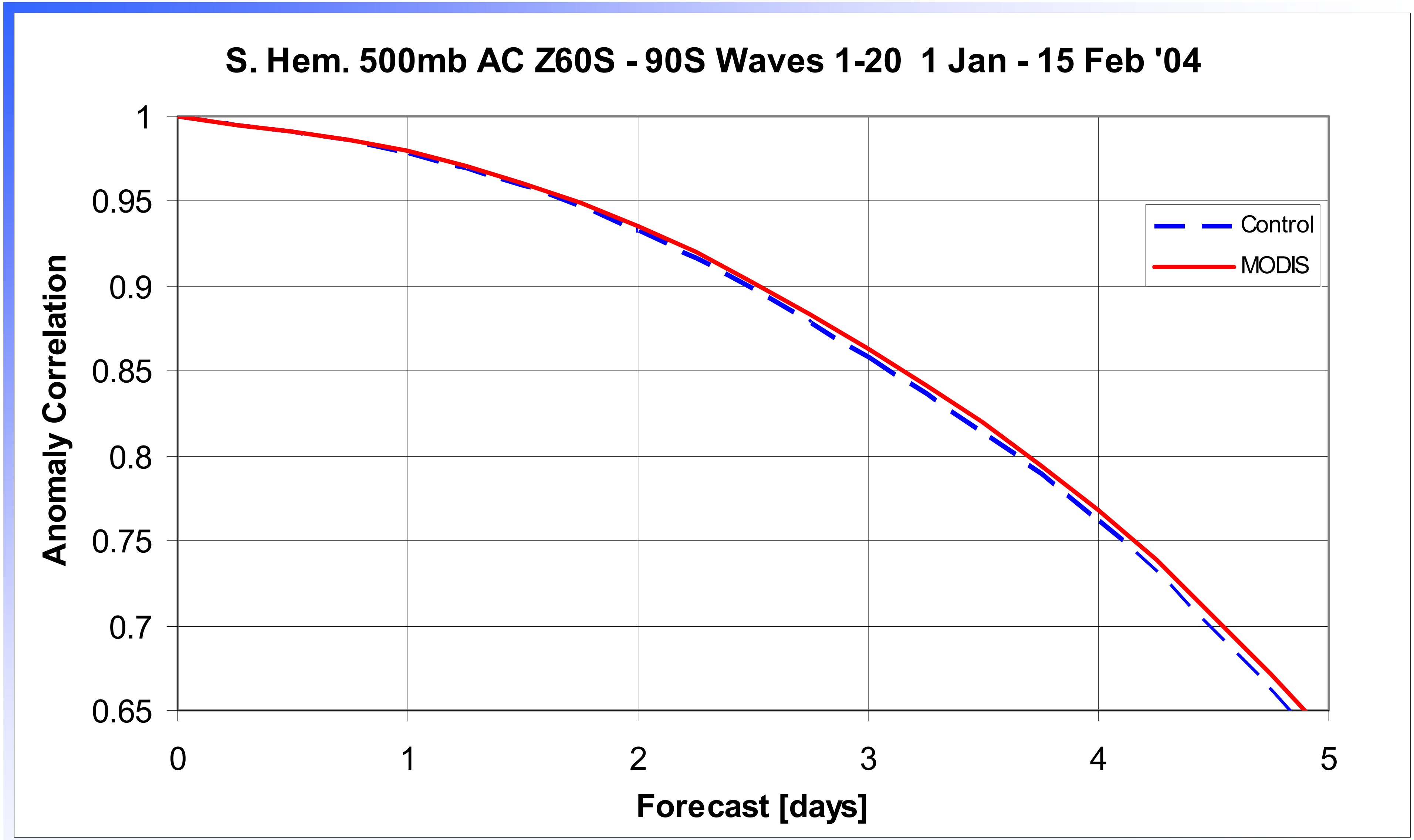


Fig. 5. The 500hPa geopotential height anomaly correlation for the Southern Hemisphere (60° S – 90° S), for the GFS control and the GFS control including MODIS AMVs, for the period 1 January to 15 February 2004.

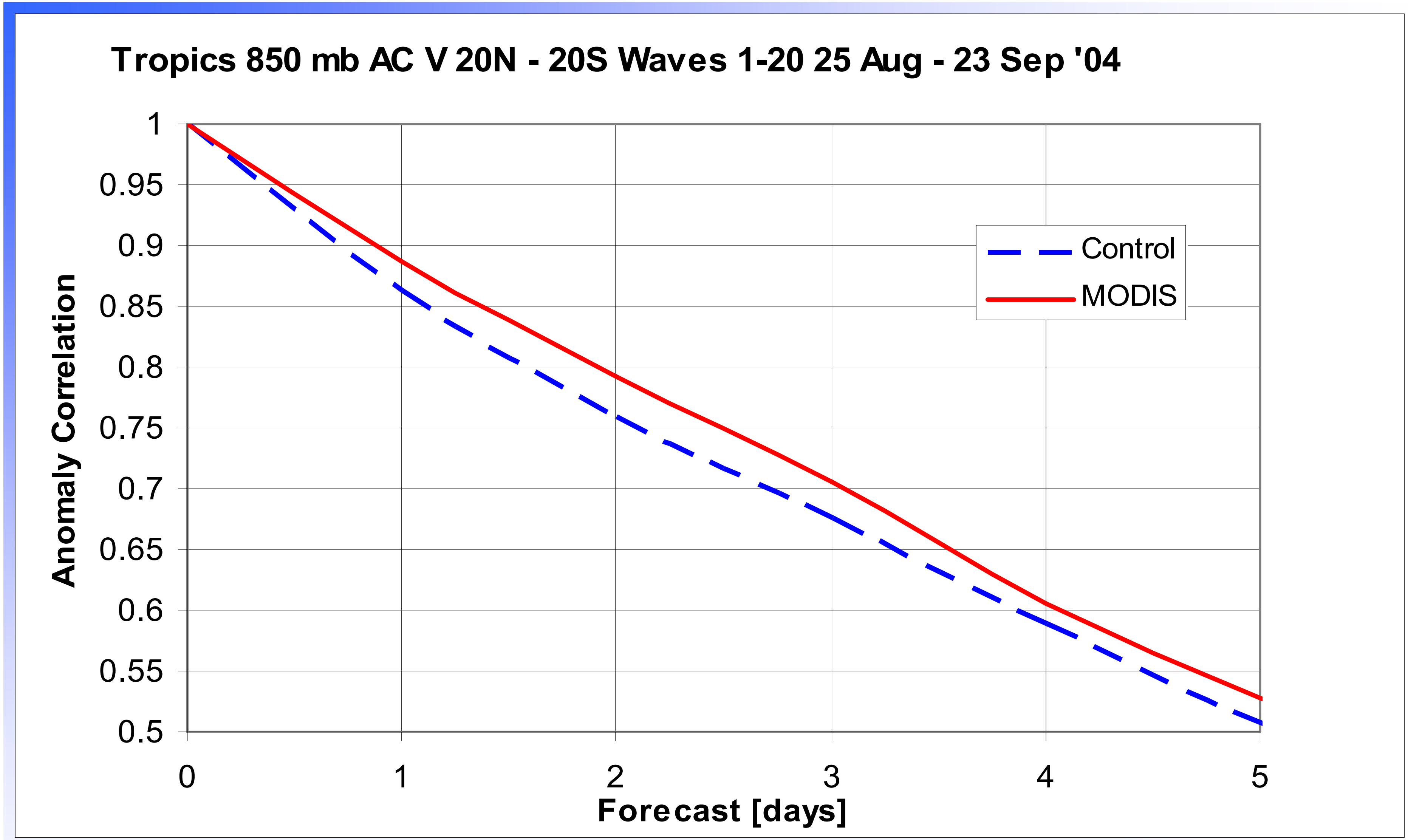


Fig. 4. The 850 hPa meridional wind component anomaly correlation for the tropical belt (20°N to 20°S), for the GFS control and the GFS control including MODIS AMVs, for the period 10 August to 23 September 2004.

2004 ATLANTIC BASIN

AVERAGE HURRICANE TRACK ERRORS (NM)

13.2	43.6	66.5	94.9	102.8	157.1	227.9	301.1	Cntrl
11.4	34.8	60.4	82.6	89.0	135.3	183.0	252.0	Cntrl + MODIS
74	68	64	61	52	46	39	34	Cases (#)
00-h	12-h	24-h	36-h	48-h	72-h	96-h	120-h	Time

Results compiled by Qing Fu Liu.

Locally Generated MTSat-1R Atmospheric Motion Vectors

Table 1. Real time schedule for MTSat-1R Atmospheric Motion Vectors at the Bureau of Meteorology. Sub-satellite image resolution, frequency and time of wind extraction and separations of the image triplets used for wind generation (ΔT) are indicated.

Wind Type	Resolution	Frequency-Times (UTC)	Image Separation
Real Time IR	4 km	6-hourly – 00, 06, 12, 18	15 minutes
Real Time IR (hourly)	4 km	Hourly – 00, 01, 02, 03, 04, 05, . . . , 23	1 hour

Quality Indicator (QI)

Considers

- Direction consistency (pair)
- Speed consistency (pair)
- Vector consistency (pair)
- Spatial Consistency
- Forecast Consistency

$$QI = \sum w_i . QV_i / \sum w_i$$

EE - provides RMS Error (RMS)

Estimated from

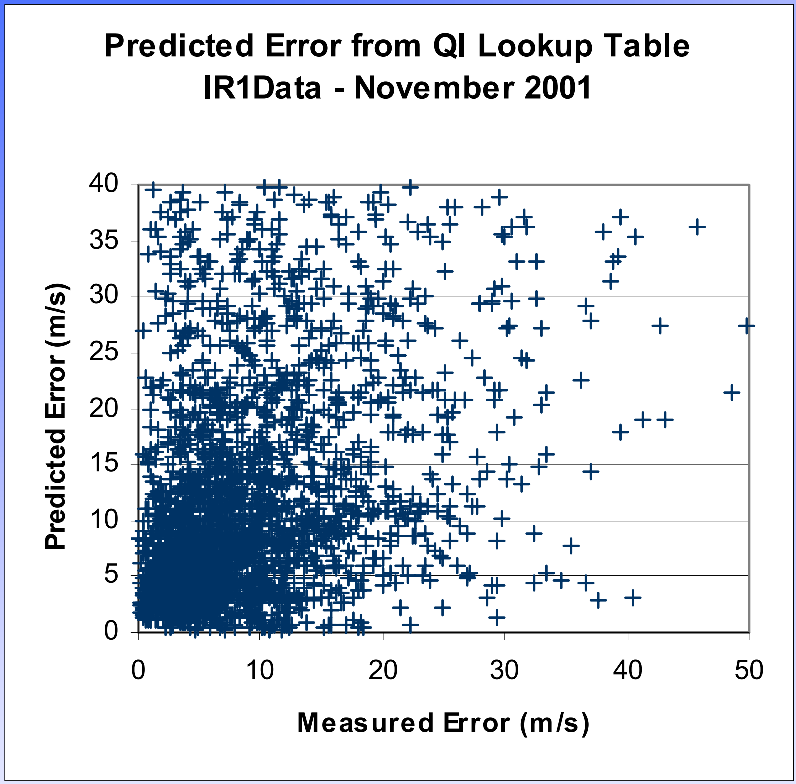
the five QI components
wind speed
vertical wind shear
temperature shear
pressure level

which are used as predictands for
root mean square error

Expected Error (EE)

$$
\begin{aligned}
EE &= \text{\_COEF} \\
&+ \text{QISP} \quad q_{sp} \\
&+ \text{QIDR} \quad q_{dr} \\
&+ \text{QIVS} \quad q_{dr} \\
&+ \text{\_QILC} \quad q_{lc} \\
&+ \text{QIFC} \quad q_{fc} \\
&+ \text{SPD} \quad V \\
&+ \text{PW} \quad P_w \\
&+ \text{\_SHEAR} \quad dV/dP \\
&+ \text{\_TEMP} \quad dT/dP
\end{aligned}
$$

where QI = Qualitiy Indicator
q_{sp} = QI for speed consistency
q_{dr} = QI for directional consistency
q_{dr} = QI for vector consistency
q_{lc} = QI for spatial consistency
q_{fc} = QI for forecast consistency
V = wind speed
P_w = pressure level assignment
dV/dP = wind shear
dT/dP = temperature shear



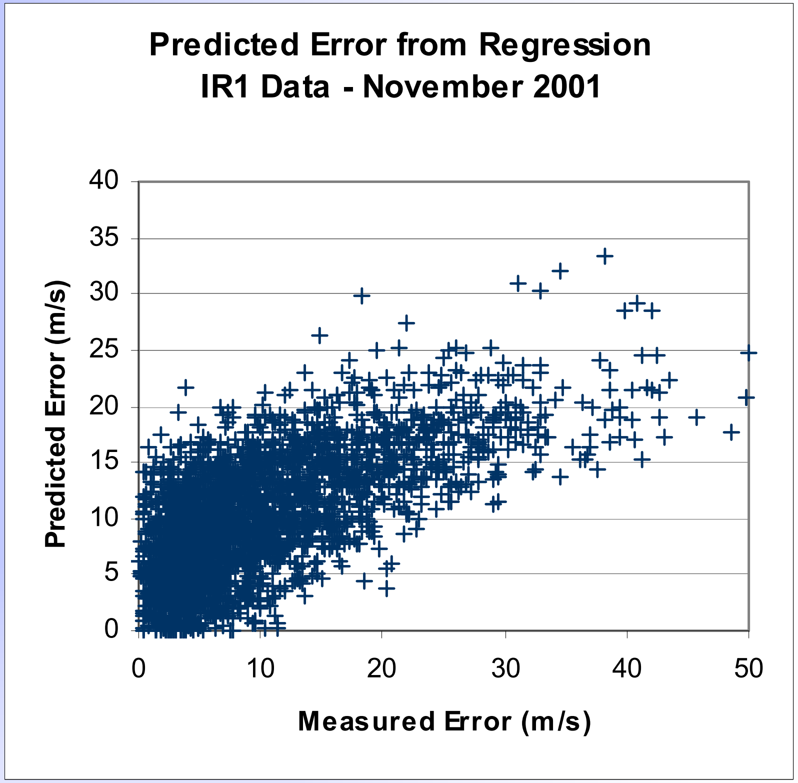


Fig. 4 (a): Predicted error using the QI lookup table

Fig. 4 (b): Predicted error using the EE regression approach

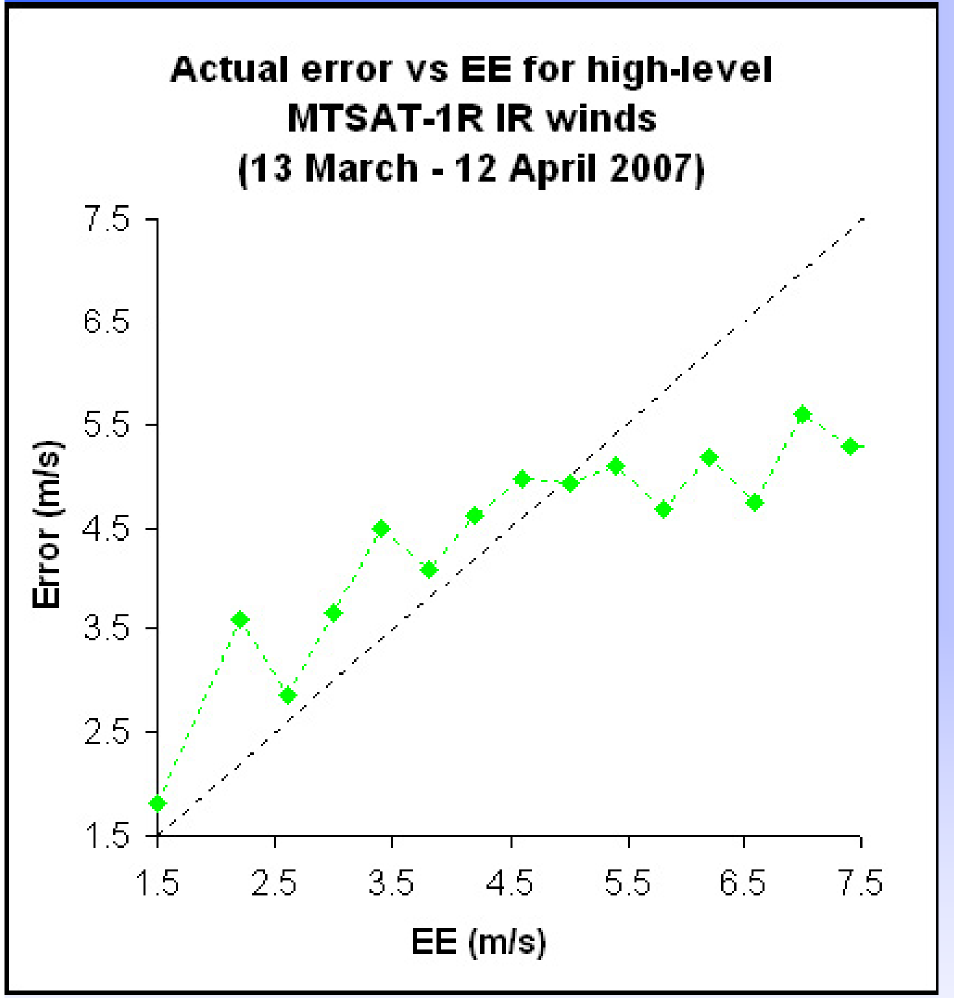
GMS-5

	EE	QI	EE	QI
Threshold	EE<5.2	QI>.98	EE<8.5	QI>.89
No. of Matches	3156	514	7265	2863
Av. MMVD	5.00	5.00	6.0	6.0
Av. Err. in MMVD	3.17	5.24	3.25	4.31

Table 3 AMV numbers and comparative errors in MMVD when selecting Upper level WV AMVs by MMVD (November, 2002) using EE and QI. (Here vectors are chosen with Av. MMVD equal to 5 and 6 ms^{-1} respectively)

The Expected Error (Le Marshall et al. 2003) is generated for MTSat-1R, GOES-10, 12 . It has recently been placed in the BUFR code used by test forecast systems (e.g. at NOAA/NESDIS) as the quality indicator, QI(EE), where

$$QI(EE) = (100 - 10.0 * EE) \qquad (1)$$



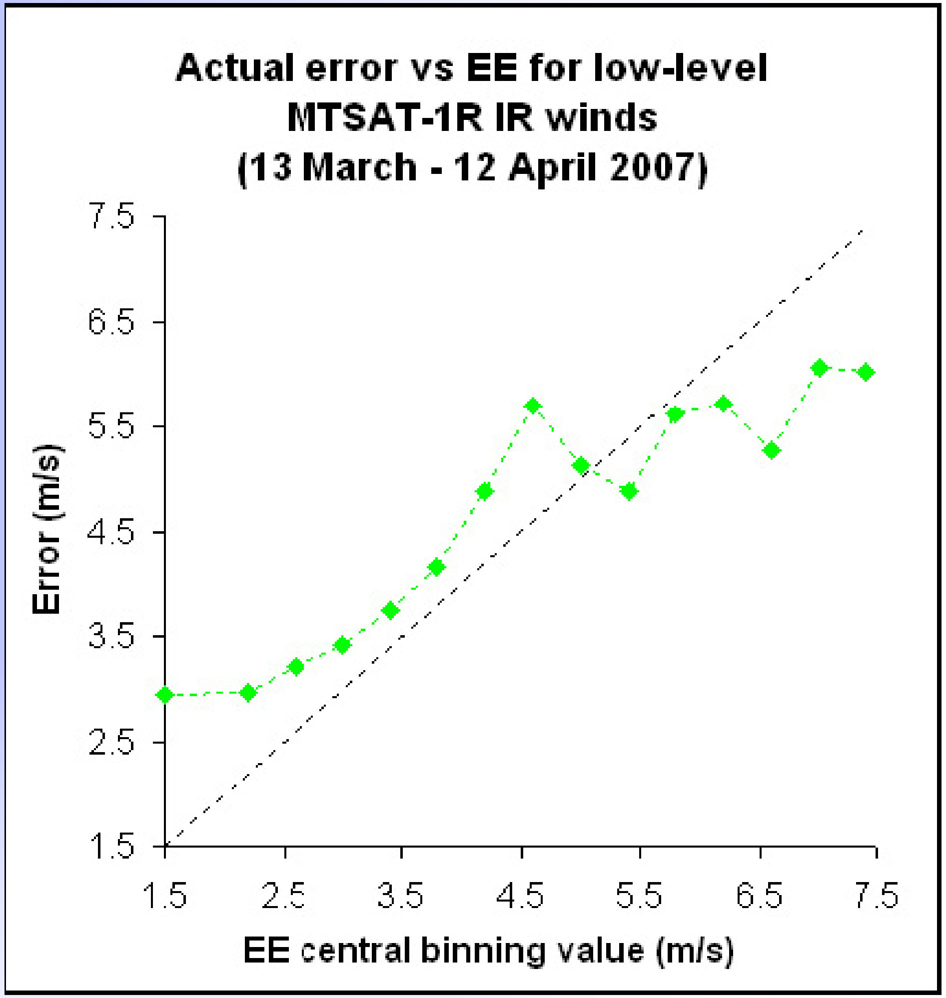


Fig. 2 (a) Measured error (m/s) versus EE for high-level MTSAT-1R IR winds (13 March - 12 April 2007

Fig. 2 (b) Measured error (m/s) versus EE for low-level MTSAT-1R IR winds (13 March - 12 April 2007)

Table 4. Mean Magnitude of Vector Difference (MMVD) and Root Mean Square Difference (RMSD) between MTSat-1R AMVs, forecast model first guess winds and radiosonde winds for the period 30 May to 15 June 2007

Level	Data Source	Bias (ms^{-1})	No. of Obs	MMVD (ms^{-1})	RMSVD (ms^{-1})
High – up to 150 km separation between radiosondes and AMVs	**AMVs**	-0.55	1386	3.90	4.47
	First Guess	1.3776	1386	4.42	5.09
Low - up to 150 km separation between radiosondes and AMVs	**AMVs**	-0.76	540	3.18	3.72
	First Guess	-0.70	540	2.72	3.12
Low – up to 30 km separation between radiosondes and AMVs	**AMVs**	-0.44	18	2.45	3.08
	First Guess	-0.20	18	2.67	3.07

Initial Results

Table 5 (a) 24 hr forecast verification S1 Skill Scores for the operational regional forecast system (LAPS) and LAPS with IR, 6-hourly image based AMVs for 30 May to 15 June 2007 (34 cases)

LEVEL	(LAPS) S1	(LAPS + MTSAT-1R AMVS) S1
1000 hPa	21.35	20.80
900 hPa	22.42	22.08
850 hPa	22.81	22.76
500 hPa	15.96	15.91
300 hPa	13.65	13.65

SSMIS Radiance Assimilation

NCEP Global Forecast System

10 August - 10 September 2005

NCEP GFS Valid September 2006

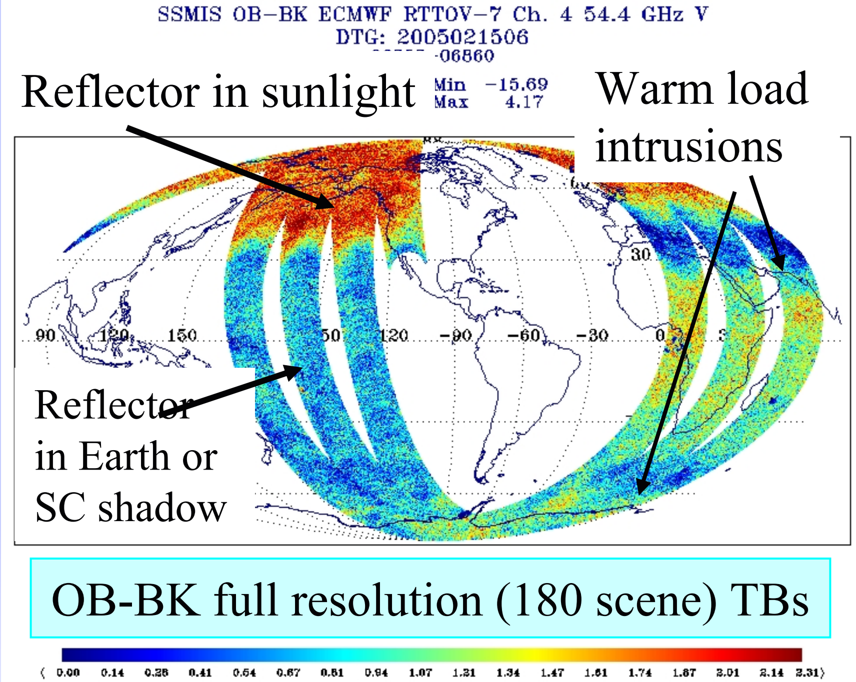
SSMIS Brightness Temperature Evaluation in a Data Assimilation Context

Collaborators: NRL: Nancy Baker (PI), Clay Blankenship, Bill Campbell. Contributors: Steve Swadley (METOC Consulting), Gene Poe (NRL)

Summary of Accomplishments

- Worked closely with Cal/Val team to understand assimilation implications of the sensor design and calibration anomalies, and to devise techniques to mitigate the calibration issues.
- Completed code to read, process, and quality control observations, apply scan non-uniformity and spillover corrections, perform beam cell averaging of footprints, and compute innovations and associated statistics.
- Developed flexible interface to pCRTM and RTTOV-7.
- Initial results indicate that pCRTM is performing well.

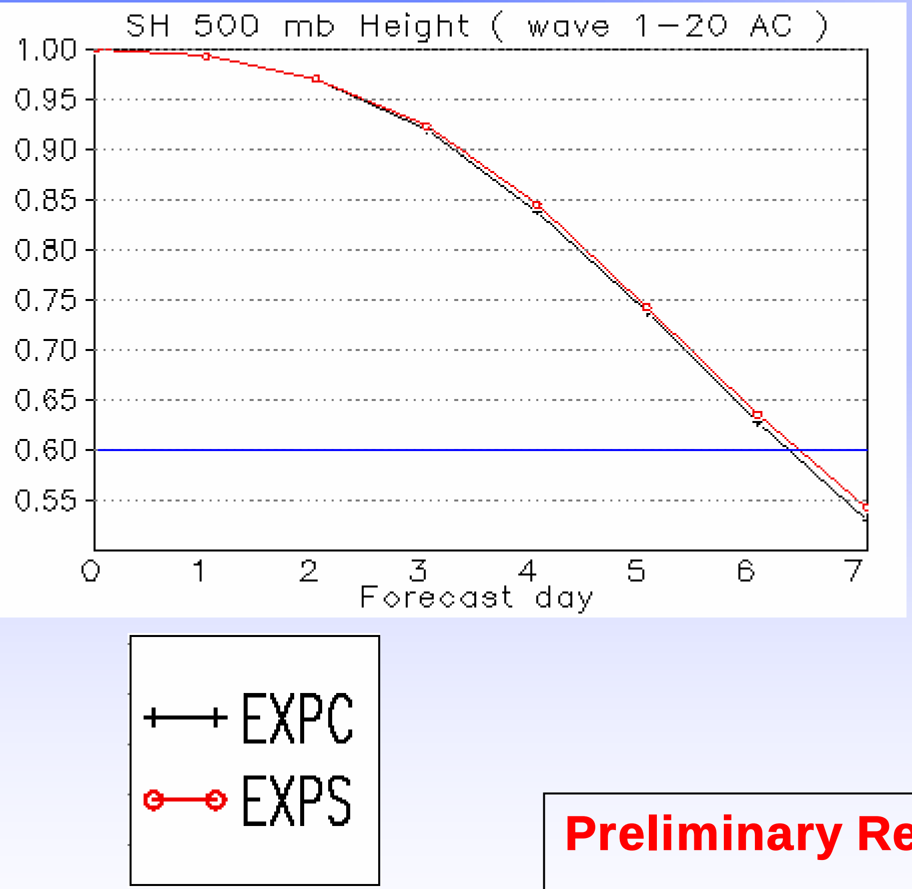
Future: Real time monitoring of SSMIS TBs. Compare pCRTM with RTTOV-7. Assess observation and forward model bias and errors; determine useful bias predictors. Assess forecast impact of SSMIS assimilation.



Chan.	pCRTM Bias	pCRTM s.d.	RTTOV-7 Bias	RTTOV-7 s.d.
4	1.70	0.54	1.68	0.53
5	1.59	1.00	1.64	0.97
6	1.81	1.24	1.83	1.24
7	3.53	1.34	3.55	1.44

SSMI/S radiance assimilation in GSI

Period:00z 10 Aug.-00z 10Sep. 2006



Assimilation System:

GSI 3D-Var

Forecast model:

NCEP Operational global model (Sep.2006)

Resolution:

T382L64

Data:

EXPC: Operational

EXPS: Operational + UKMO SSMIS data

(removed flagged data)

Preliminary Results:

Improved A.C. 500 hPa height in the S.H.

Required further investigation on data quality

NCEP AMSR-E Radiance Assimilation

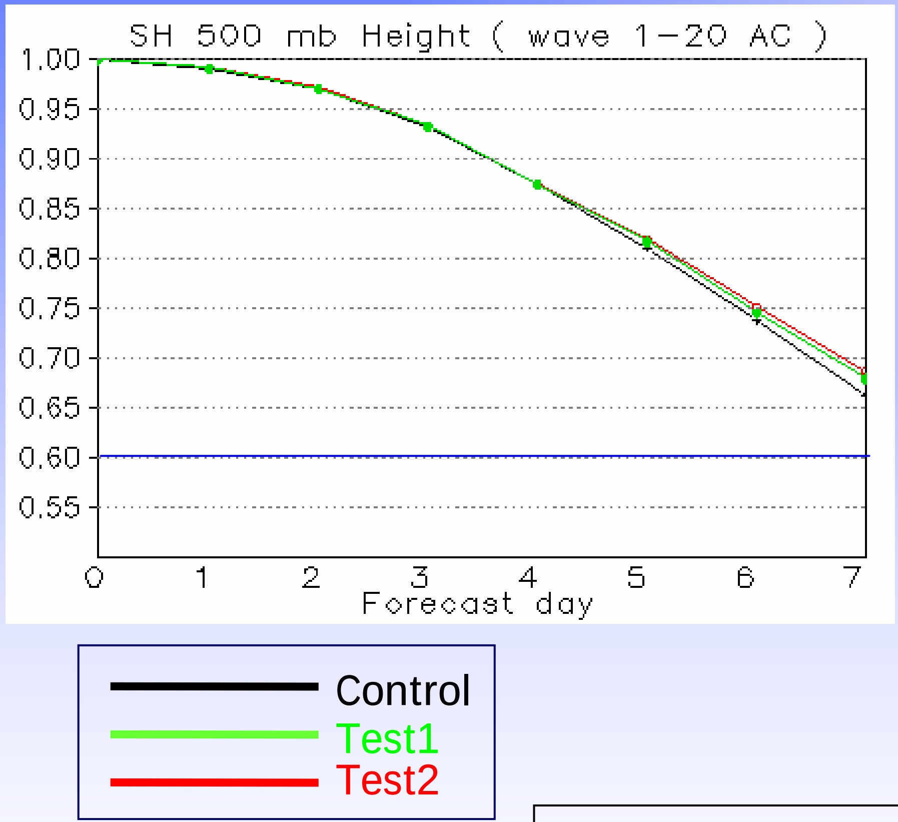
Period
  2-week cycling (Aug. 12, 2005 - Sept. 11, 2005)

System
  Analysis: GSI (May. 2006 release version)
    + New MW Ocean emissivity model
  Forecast: operational forecast model
    Resolution: T382L64

Data set
  Cntl: same as operational
  Test: Cntl + AMSR-E radiance data

AMSR-E radiance assimilation in GSI

Period:00z 12 Aug.-00z 11 Sep. 2005



Assimilation System:

GSI 3D-Var

Forecast model:

NCEP Operational global model (May.2006)

Resolution:

T382L64

Data:

Control: Operational

Test1: Operational + AMSR-E (FASTEM1)

Test2: Operational + AMSR-E (New EM)

Results:

Improved A.C. 500 hPa height in the S.H.

Decrease of RMS of surface wind speed analysis increment

Assimilation of GPS RO observations at JCSDA

Lidia Cucurull, John Derber, Russ Treadon, Martin Bohman, Jim Yeo…

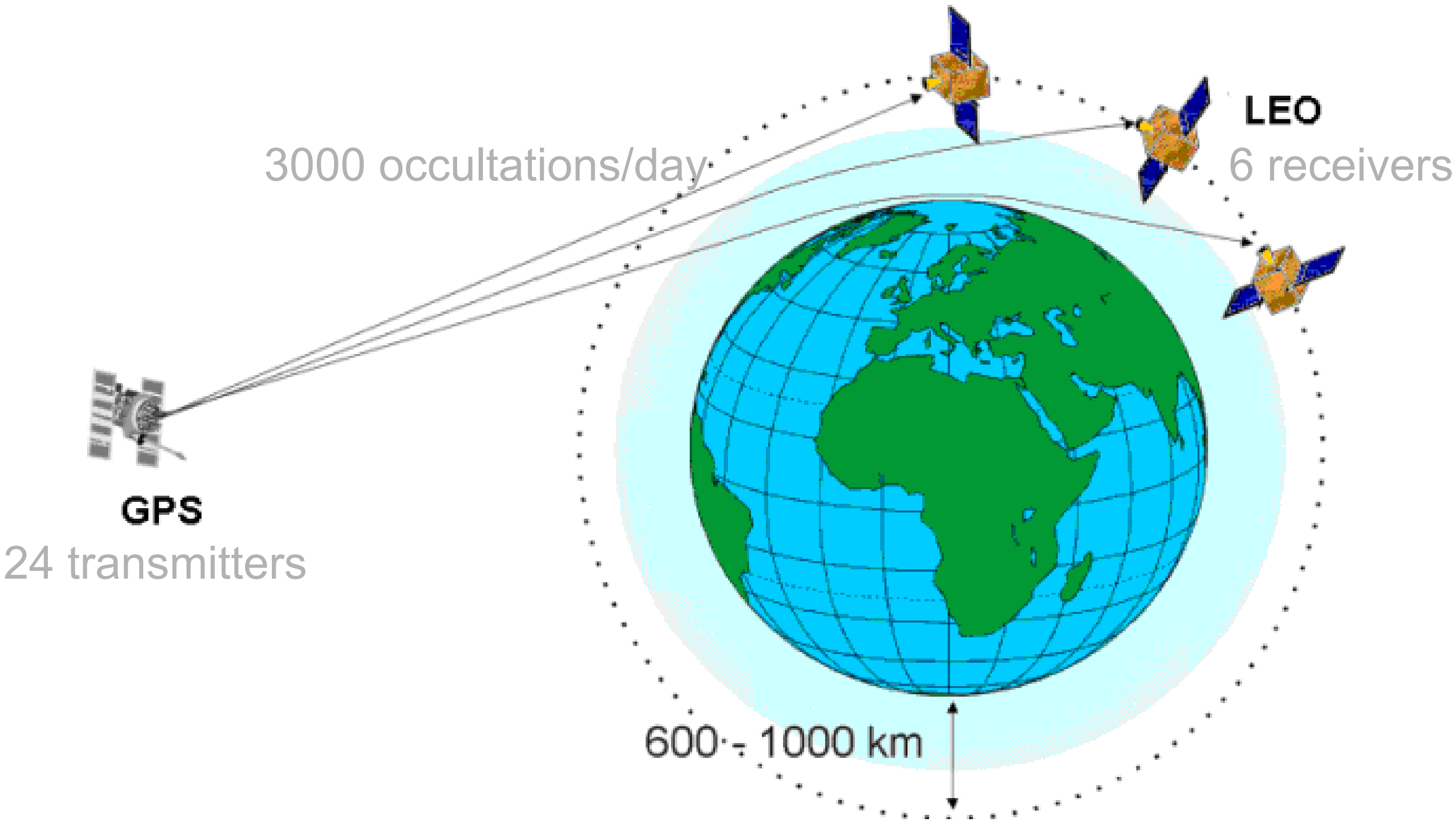
COSMIC :

- The COnstellation of Satellites for Meteorology, Ionosphere, and Climate
- A Multinational Program
  - Taiwan and the United States of America
- A Multi-agency Effort
  - NSPO (Taiwan), NSF, UCAR, NOAA, NASA, USAF
- Based on the GPS Radio Occultation Method

COSMIC (cont'd):

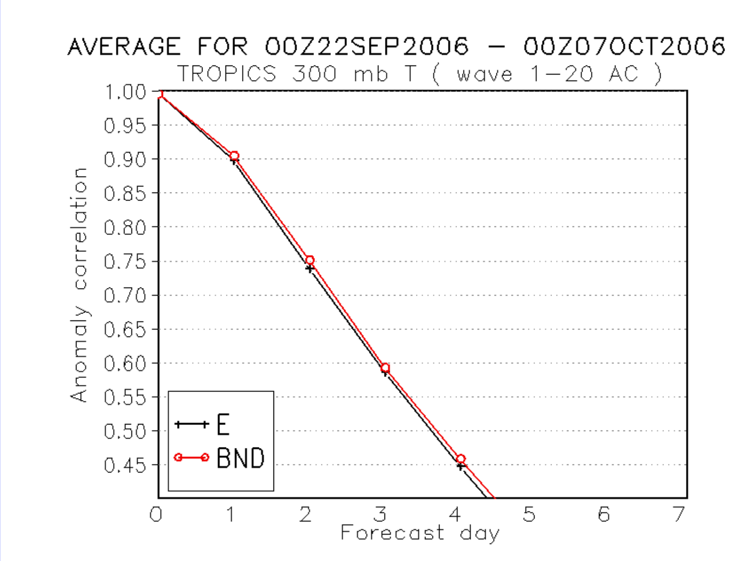
- Launched 14 April 2006
- Lifetime 5 years
- Operations funded through March 08

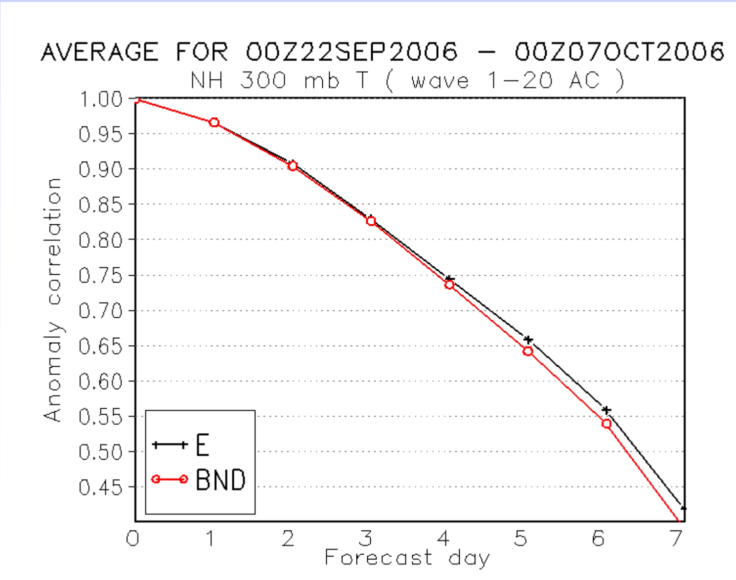
GPS/COSMIC

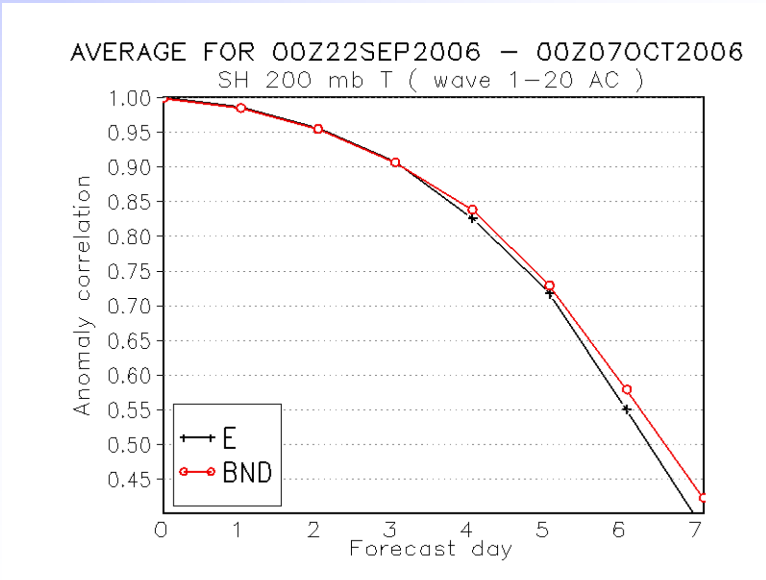

LEO
6 receivers
3000 occultations/day
GPS
24 transmitters
600 - 1000 km

First impact experiments (T382) with COSMIC

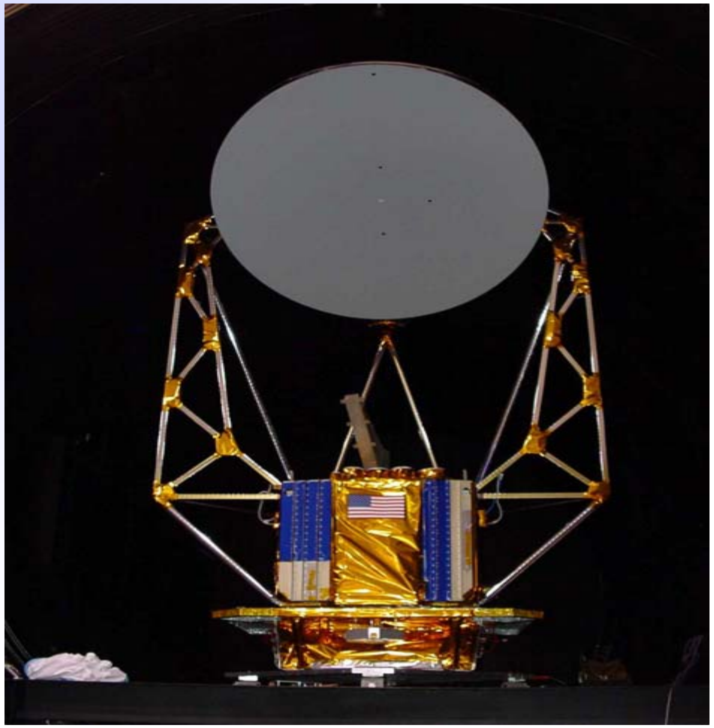
- Anomaly correlation as a function of forecast day for two different experiments:
  - –E (assimilation of operational obs),
  - –BND (E + COSMIC bending angle).
- Only COSMIC observations available in operations have been used in BND.
- Only COSMIC observations < 30 km







USE OF SURFACE WIND VECTORS AT THE JCSDA



J.Le Marshall

JCSDA WindSat Testing

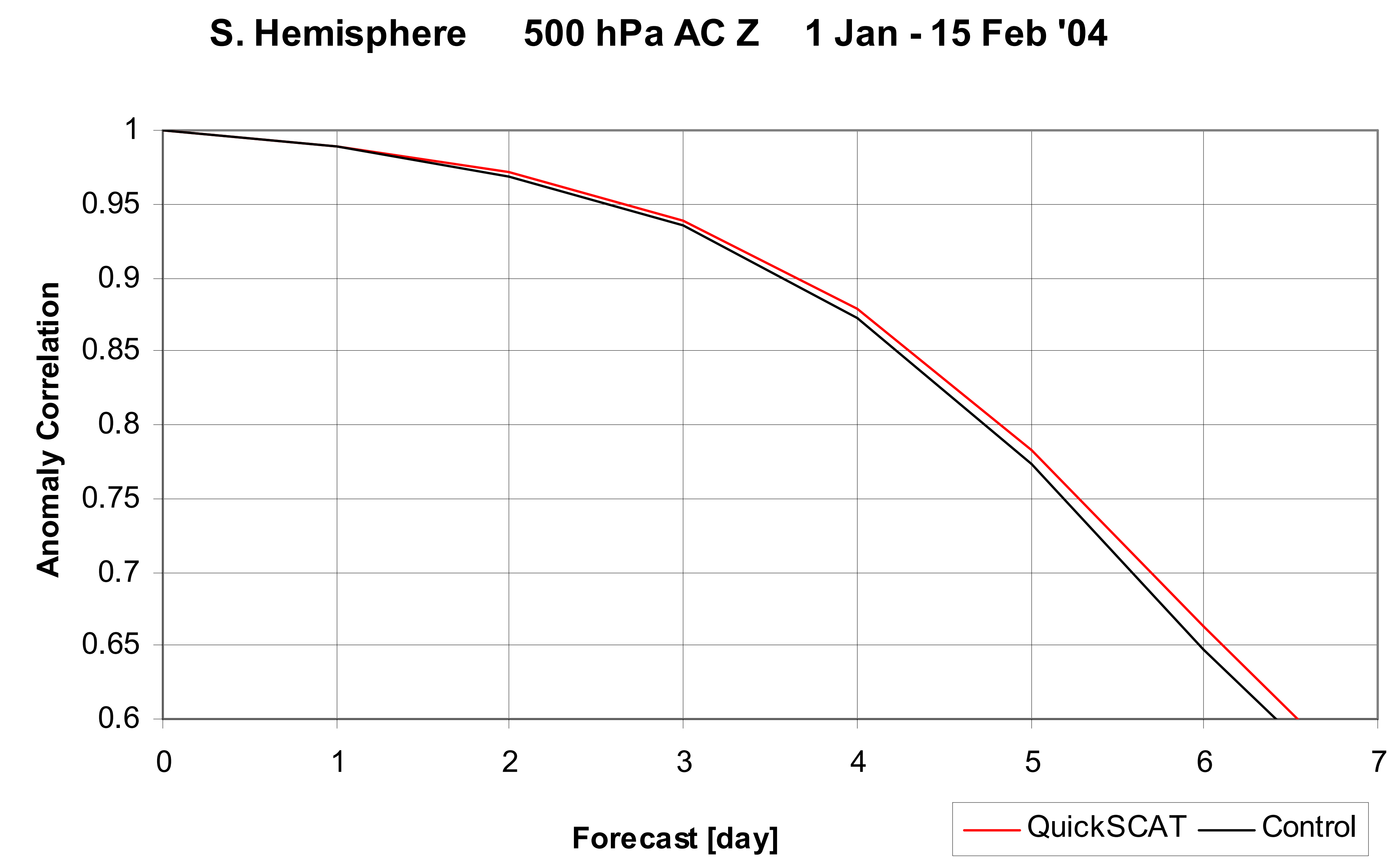
- **Coriolis/WindSat data is being used to assess the utility of passive polarimetric microwave radiometry in the production of sea surface winds for NWP**

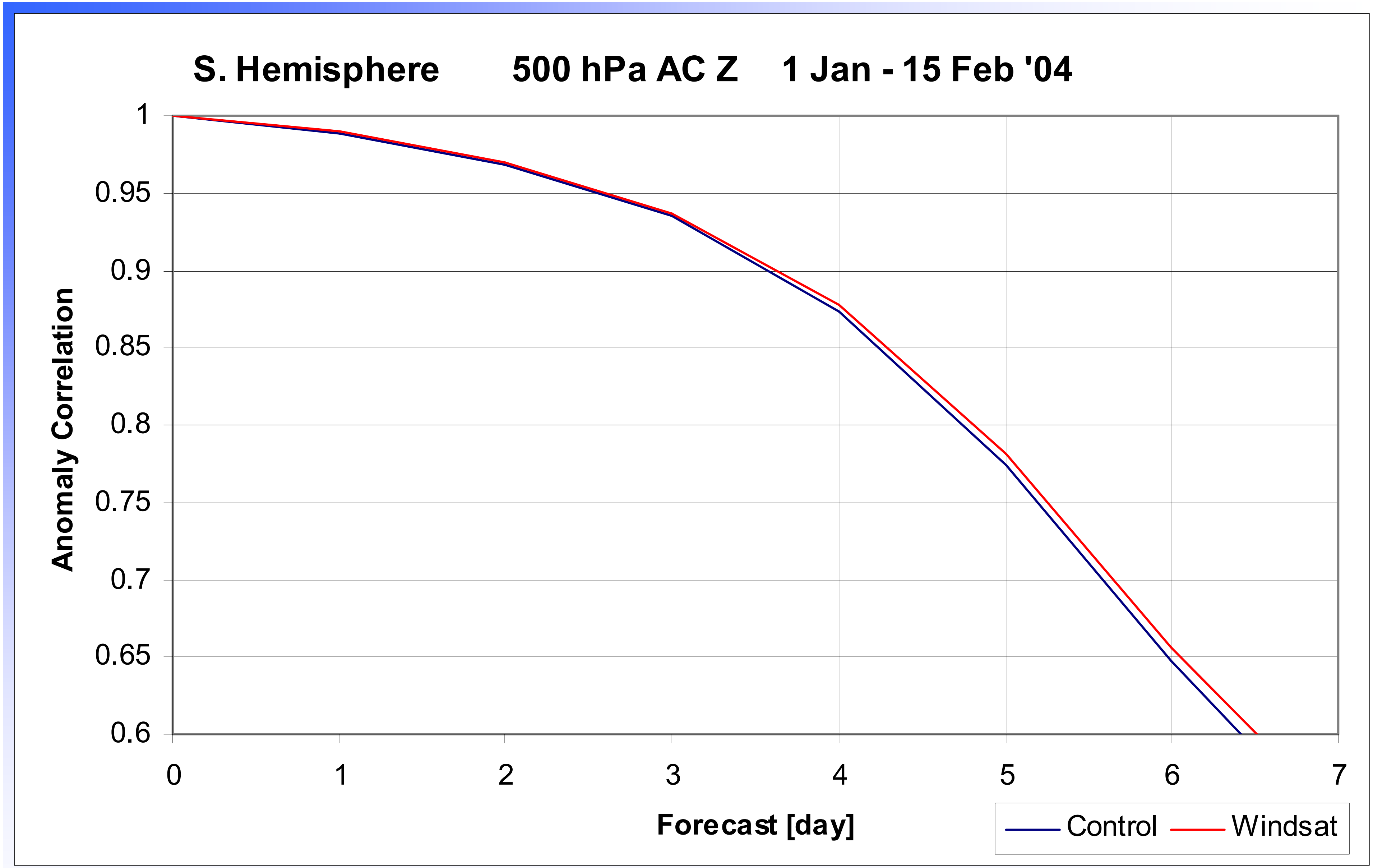
- **Study accelerates NPOESS preparation and provides a chance to enhance the current global system**

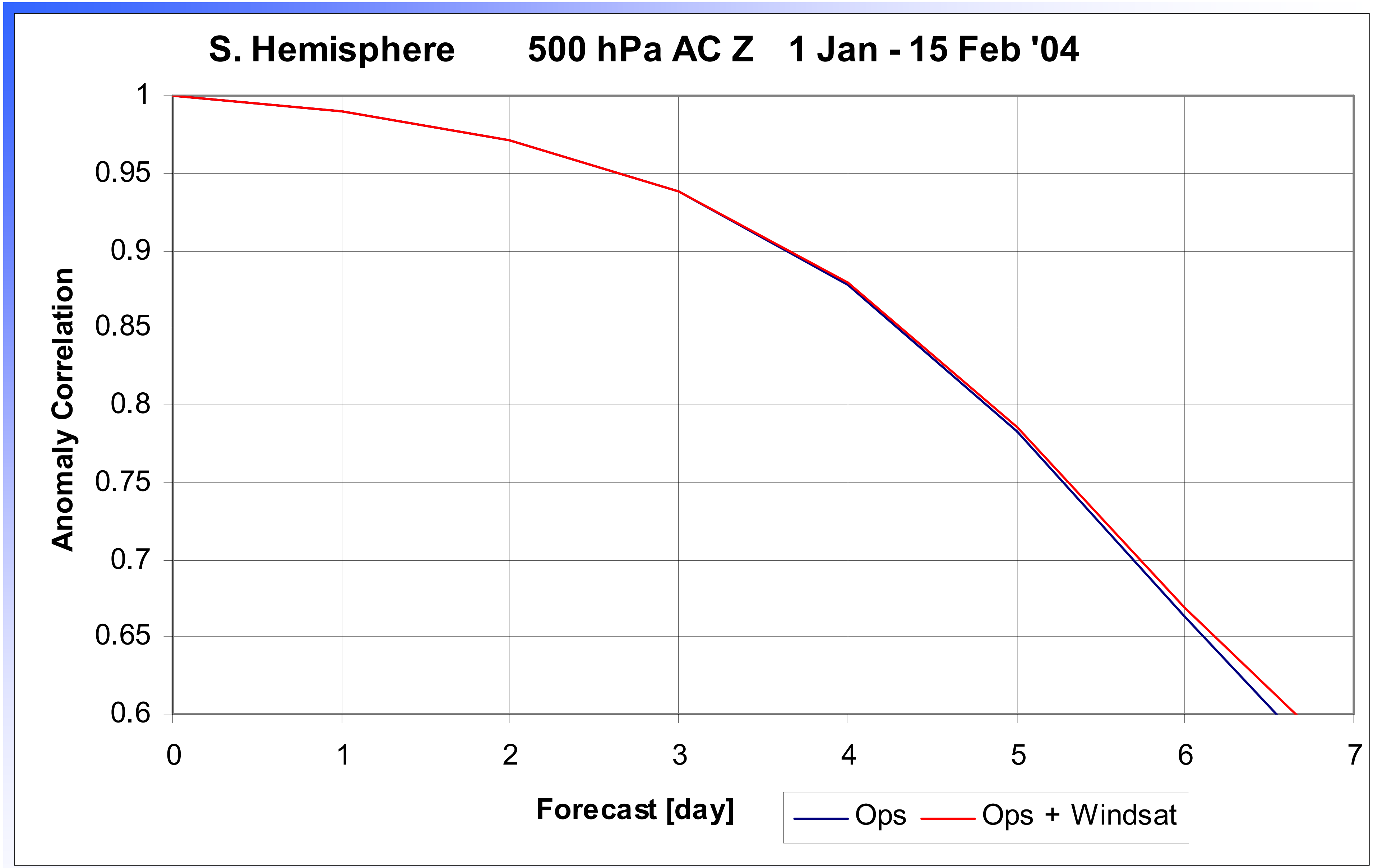
- **Uses NCEP GDAS**

JCSDA WindSat Testing

- **Experiments**
  - **Control with no surface winds (Ops minus QuikSCAT)**
  - **Operational QuikSCAT only**
  - **WindSat only**
  - **QuikSCAT & WindSat winds**


S. Hemisphere 500 hPa AC Z 1 Jan - 15 Feb '04
Anomaly Correlation
1
0.95
0.9
0.85
0.8
0.75
0.7
0.65
0.6
0
1
2
3
4
5
6
7
Forecast [day]
QuickSCAT
Control

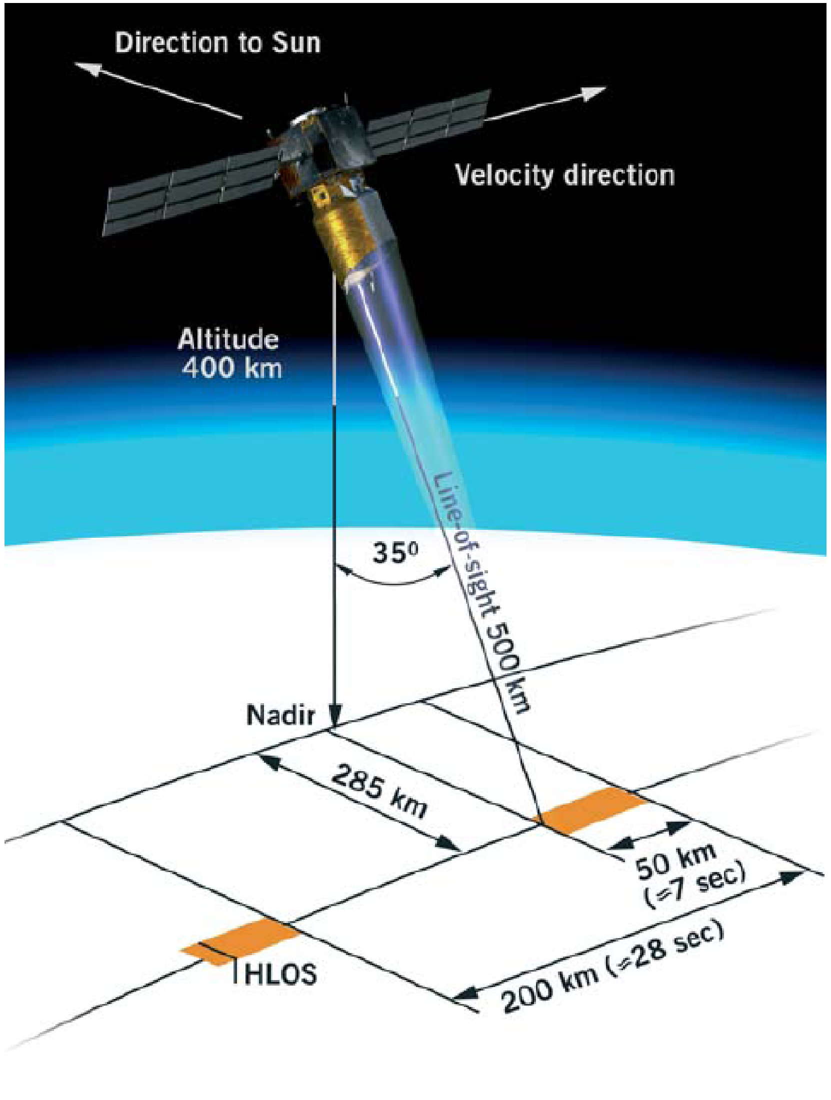

S. Hemisphere 500 hPa AC Z 1 Jan - 15 Feb '04
Anomaly Correlation
1
0.95
0.9
0.85
0.8
0.75
0.7
0.65
0.6
0
1
2
3
4
5
6
7
Forecast [day]
Control
Windsat



S. Hemisphere 500 hPa AC Z 1 Jan - 15 Feb '04
Anomaly Correlation
1
0.95
0.9
0.85
0.8
0.75
0.7
0.65
0.6
0
1
2
3
4
5
6
7
Forecast [day]
Ops
Ops + Windsat

ADM-Aeolus
An Earth Explorer Mission

Preparing for a new instrument with an OSSE study



Baseline Aeolus measurement geometry. The wind is observed orthogonal to the satellite ground-track, pointing 35° off-nadir, away from the Sun. Observations cover 50 km along the flight direction, and are spaced 200 km apart. (H)LOS means (horizontal) line of sight.

The ADM-Aeolus mission is planned to meet the following set of observational requirements:

	PBL(*)	Troposphere	Stratosphere
Height range	0-2 km	2-16 km	16-20 km
Vertical resolution	0.5 km	1.0 km	2.0 km
Horizontal domain		global	
Number of profiles		100 / hour	
Profile separation		>200 Km	
Temporal sampling		12 hours	
Accuracy (component)	2 m/s	2-3 m/s	3 m/s
Horizontal integration		50 km	
Timeliness		3 hours	
Length of observational data set		3 yrs	

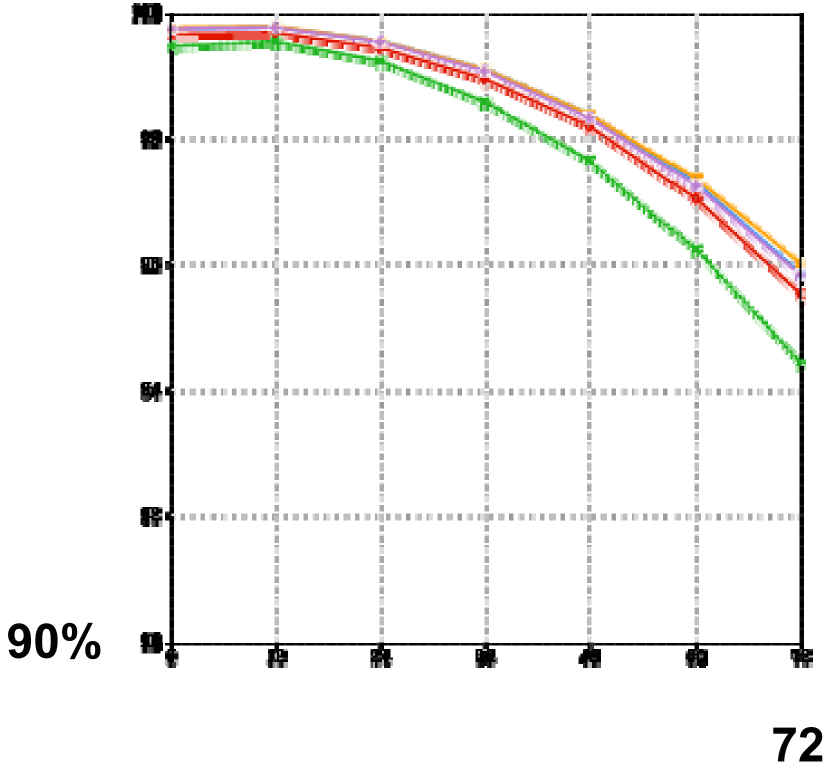
(*) PBL = planetary boundary layer
This table outlines the measurement requirements for the Aeolus-ADM mission. These are based on information gained from the WCRP and other organisations, which specify the accuracy and complexity of data required by the scientific and meteorological community.

ADM – DWL OSSE

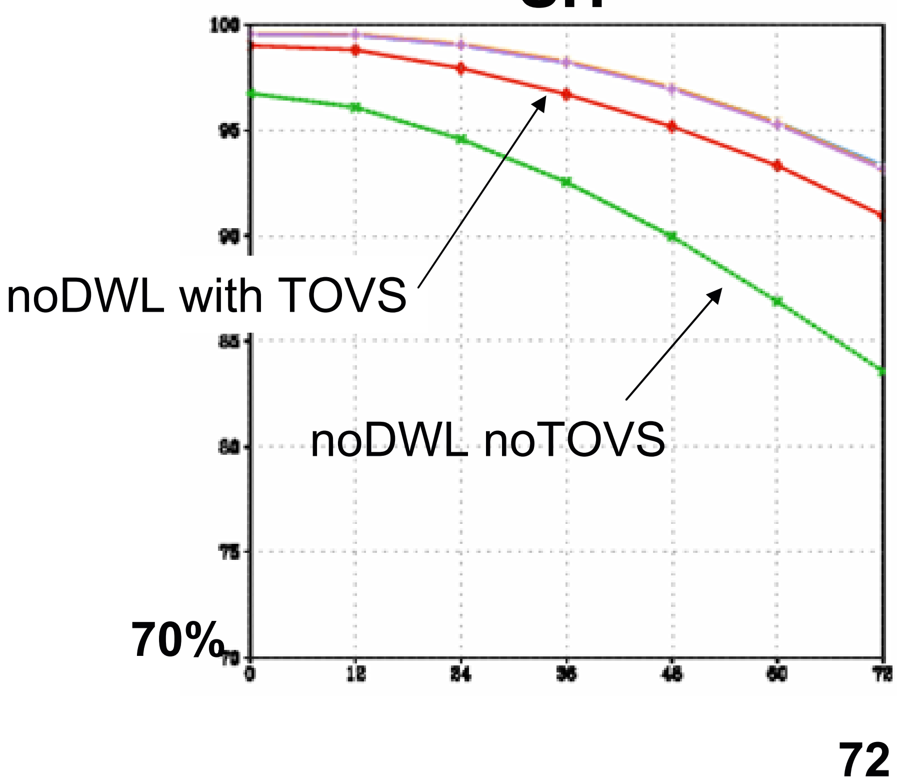
AC v. Nature run
500hPa height
Total scale

100%L+ 0%U
100%L+100%U
100%L+10%U
NODWL
NODWL NOTOVS

NH



SH



Summary

•JCSDA is being positioned to exploit the observational data base to be provided by the GEOSS in terms of:

- Assimilation science
- Modeling science.
- Computing power

Key components of the operational data base have been assessed in terms global forecast impact.

Quantitative estimates (ACs, FIs and hurricane forecast track errors) have been used to quantify the impact of conventional data, satellite data, and that of particular instruments and rawinsonde data in a number of OSEs. The importance of AMSU, AIRS and rawinsondes was noted.

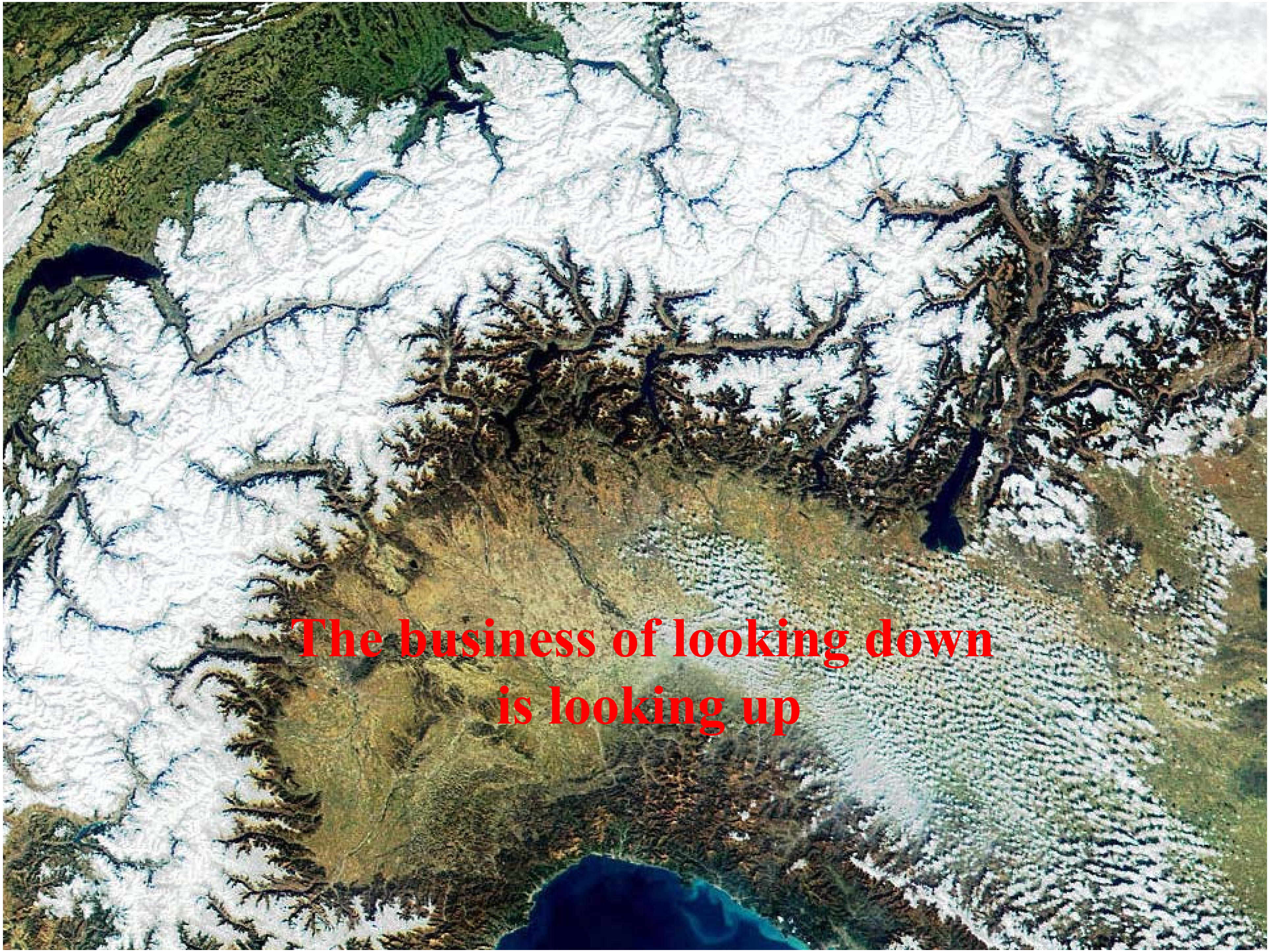
Summary

The importance of AIRS was also shown and the significant potential for enhanced use of these hyperspectral radiances was also demonstrated.

Data impact studies for several new instruments/data streams were also described.

Overall the JCSDA has now used data from over 40 instruments for analysis and the potential for further improvement from enhanced usage of current data and the benefits from future observing systems is significant.

The Joint Center will play a key role in enabling the use of advanced satellite data, from both current and future advanced systems, for environmental modeling. The USA and the Global Community will be significant beneficiaries from the Centers activity.


The business of looking down
is looking up

JOINT CENTER FOR SATELLITE DATA ASSIMILATION

NOAA NASA JCSDA Navy Air Force