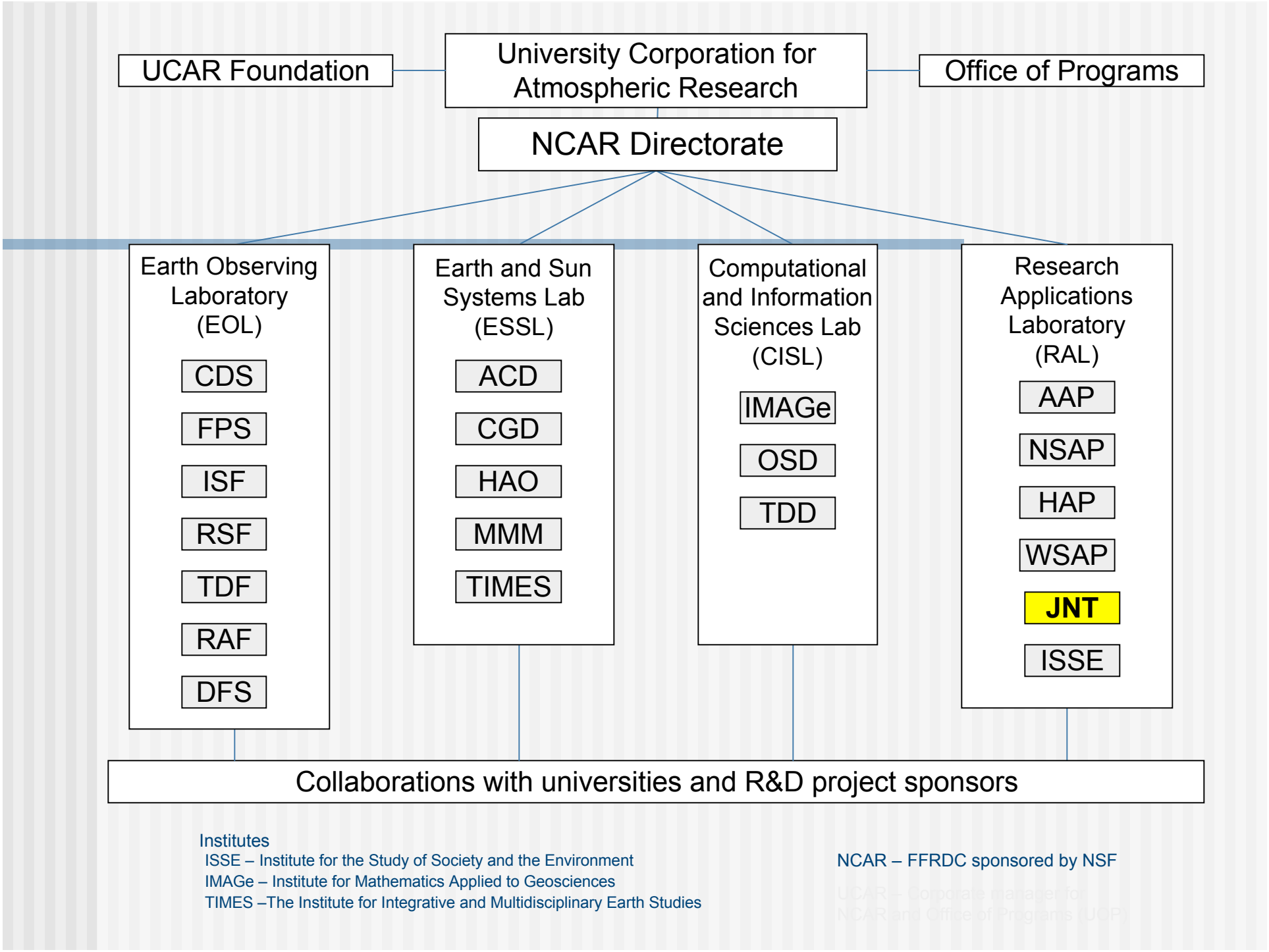
Applications of WRF Data Assimilation System at the NCAR Data Assimilation Testbed Center

Hui Shao

Coauthors: Hans Huang, Hui Shao, Meral Demirtas, Zhiquan Liu,
Rizvi Syed, Thomas Auligne, Hui-Chuan Lin
National Center for Atmospheric Research
&
Dale Barker
National Center for Atmospheric Research
United Kingdom MetOffice

Special acknowledgement to NCAR/MMM WRF and WRF-Var development group and NCAR/CISL computational support. Acknowledgement also to NSF, AFWA, KMA, CAA & NASA for their sponsorships.



Institutes
ISSE – Institute for the Study of Society and the Environment
IMAGe – Institute for Mathematics Applied to Geosciences
TIMES –The Institute for Integrative and Multidisciplinary Earth Studies

NCAR – FFRDC sponsored by NSF
UCAR – Corporate manager for NCAR and Office of Programs (UOP)

Joint Numerical Testbed

Bob Gall, Director
Deputy Directors: Sci: Hans Huang, Louisa Nance
SE: Laurie Carson

Developmental Testbed Center (DTC)
Bob Gall

Data Assimilation Testbed Center (DATC)
Hans Huang

Space Weather Prediction Testbed
Michael Wiltberger

TBD

TBD

Data Assimilation Testbed Center

Testing and evaluation of DA systems

Testing and evaluation of observation impact

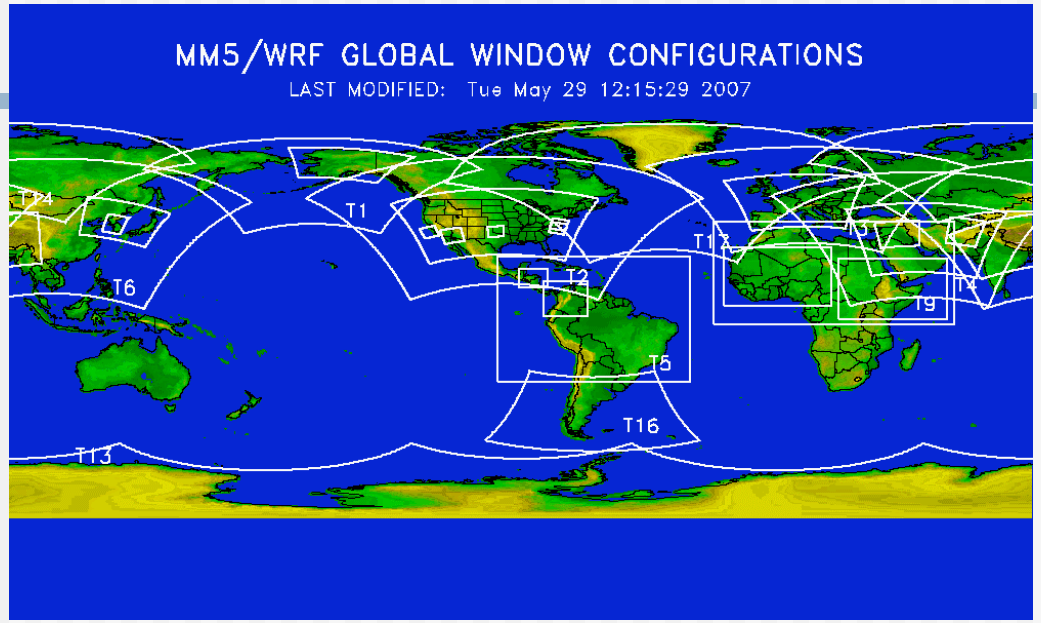
Testing and evaluation of advanced DA techniques

User support (with MMM, …): tutorials, documentation

Link operations and research

DATC Project Status

- Core funding for testing WRF-ARW/WRF-Var in AFWA theaters:



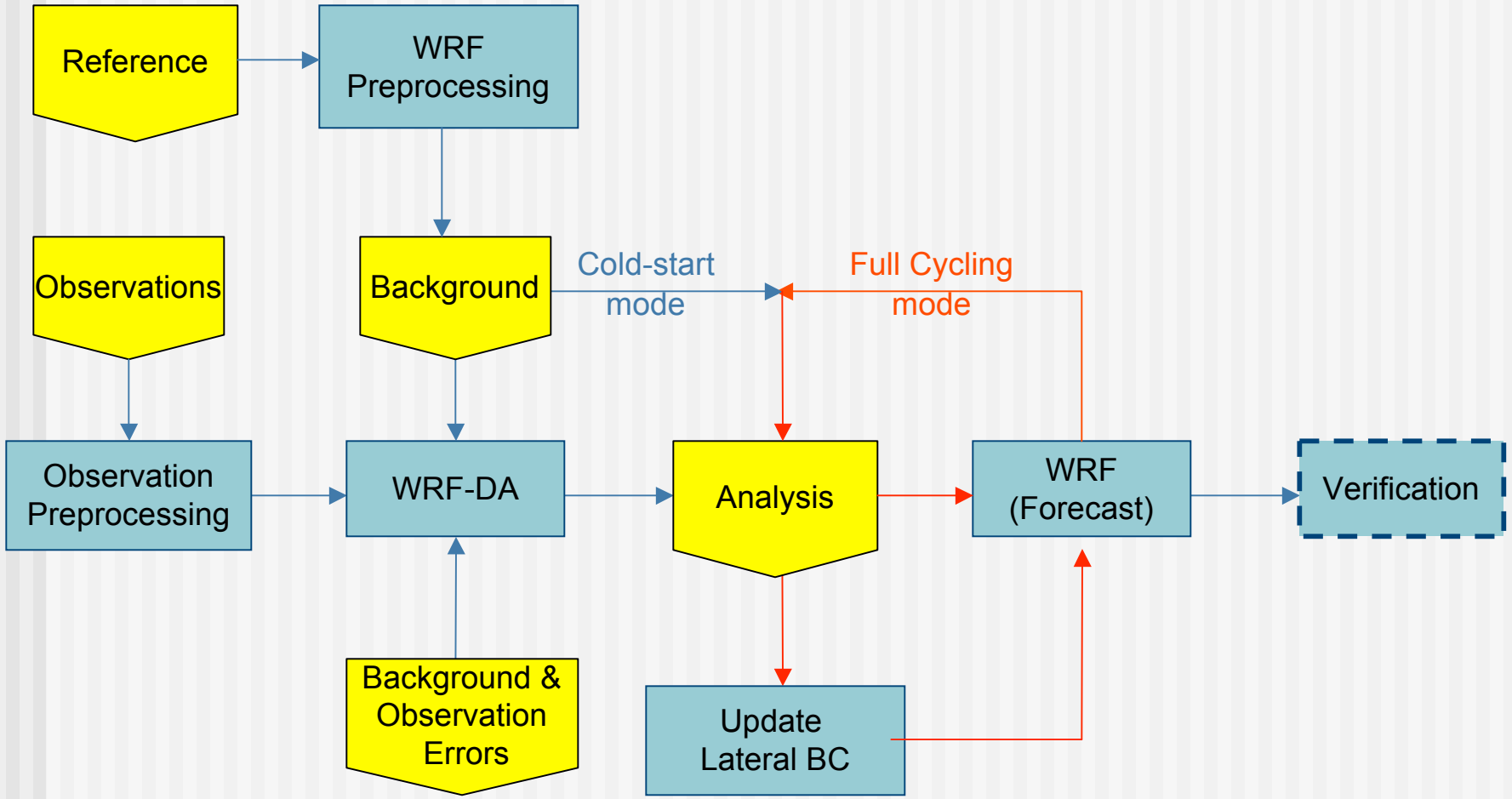
- Several new project testbeds added in 2007:
  - Antarctic Mesoscale Prediction System (AMPS - funded by NSF/OPP).
  - Taiwanese Civil Aeronautics Administration (CAA).
  - Korean Meteorological Administration (KMA).

  All testbeds involve extended-period testing of new components of DA system.
- Arctic reanalysis
- International visitors

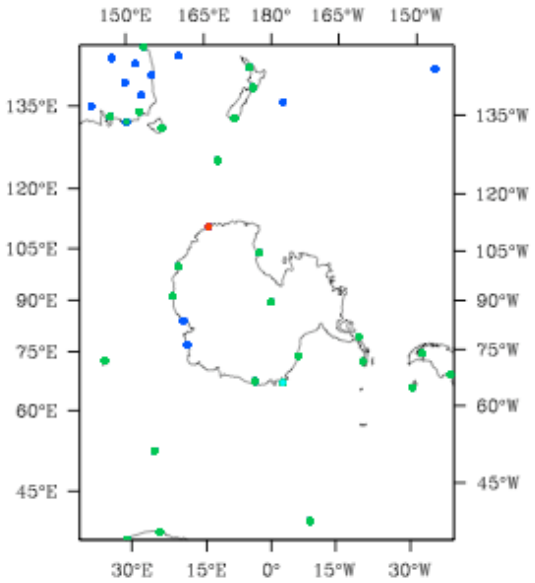
DATC Testbed Strategy

- Define **reference configuration**:
  - **Model:** e.g. WPS or SI, WRF-ARW or NMM, WRF-Var or GSI, etc.
  - **Namelists:** Defines domain, how model components will be run, etc.
  - **Period:** Typically >= 1 month. Choice based on scientific (significant events, new instruments) and practicalities (deadlines, available data).
  - **Suite:** Scripts that define how model components are combined.
  - **Verification:** How results will be validated.
- 2) Run "benchmark" defined by above reference configuration.
- Perform "sensitivity" tests by varying components of the reference configuration (typically only **namelists** are modified).

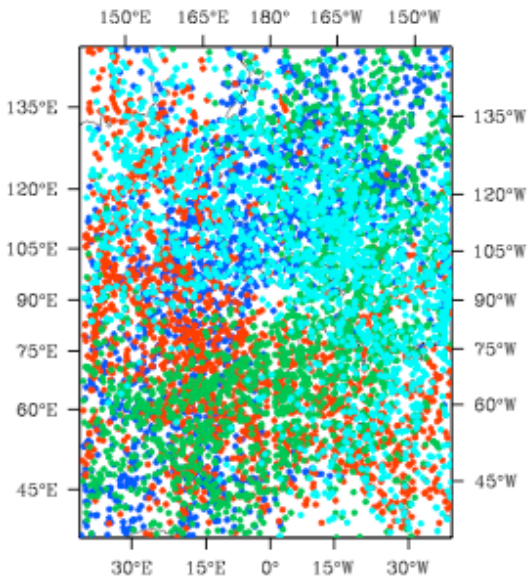
DATC WRF and WRF Data Assimilation End-To-End System



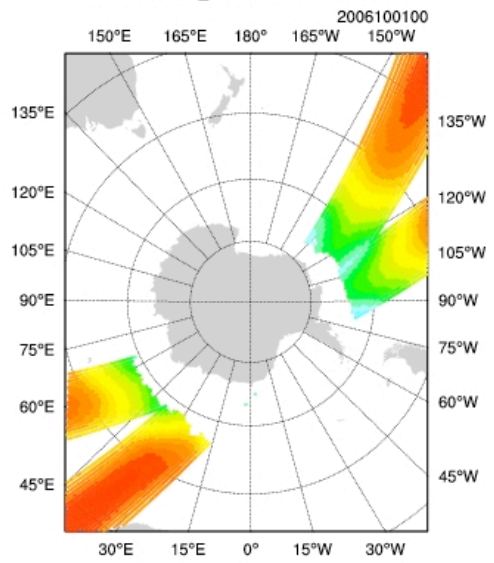
DATC Antarctica Testbed



Sonde Sites



COSMIC 1mon Coverage



AMSU-A Radiance CH7 4hr Coverage

Testbed Configuration (from MMM/AMPS):

- **Model:** WRF-ARW, WRF-Var (version 2.2).
- **Namelists:** 60km (165x217), 31 vertical levels, 240s time step.
- **Period:** October 2006.
- **Suite:** NODA, 3D-Var (6-hourly full cycling).
- **Purpose**: Model configuration, Satellite obs impact (COSMIC, AMSU-A, AIRS),..

Sensitivity of Model Forecast to Model Top Configuration

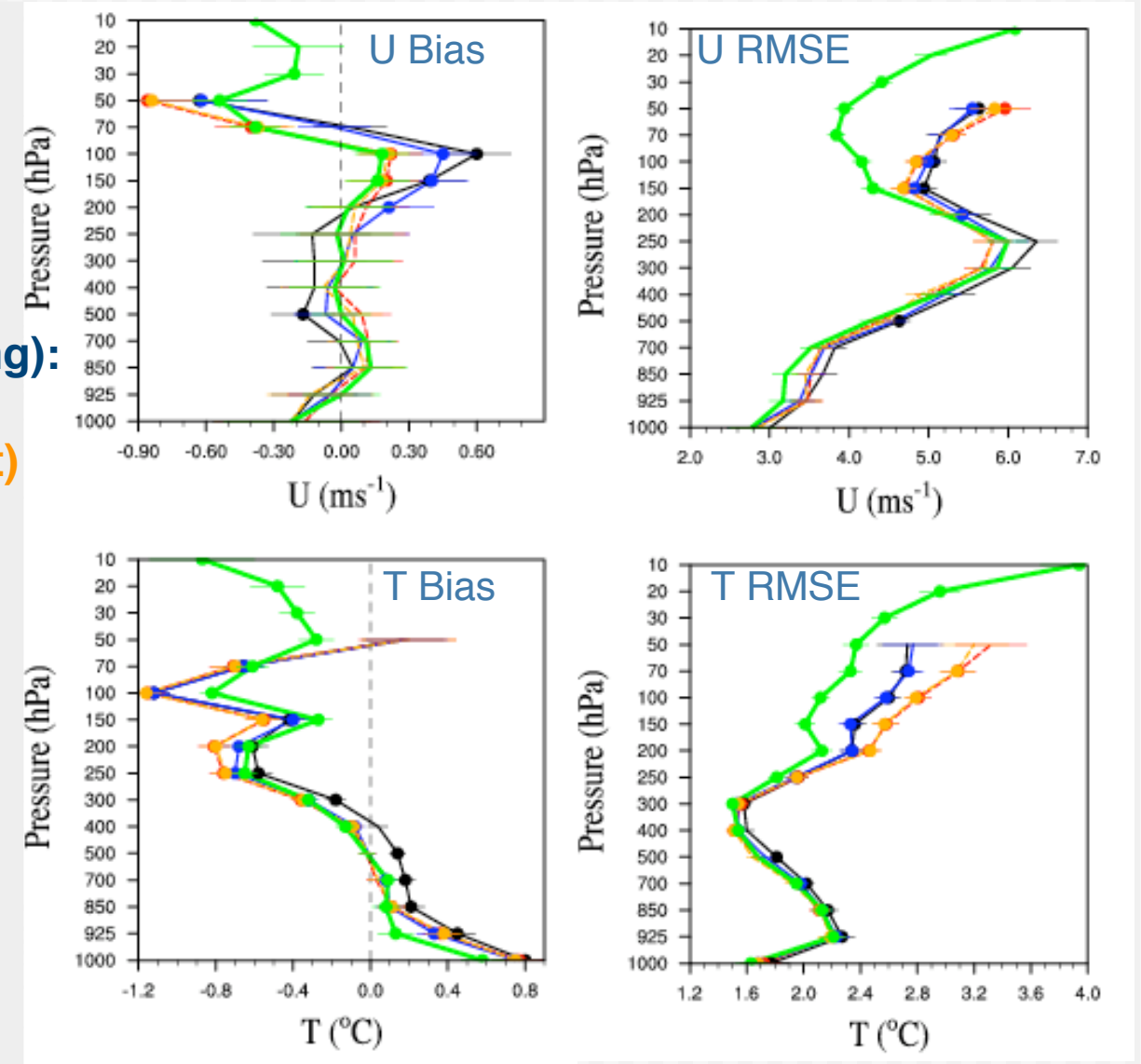
(36hr Forecast Verification Against Sondes)

(From Hui Shao)

Experiments (Full cycling):

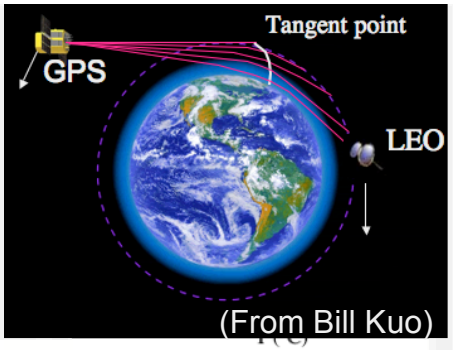
GTS + 50mb top (default)

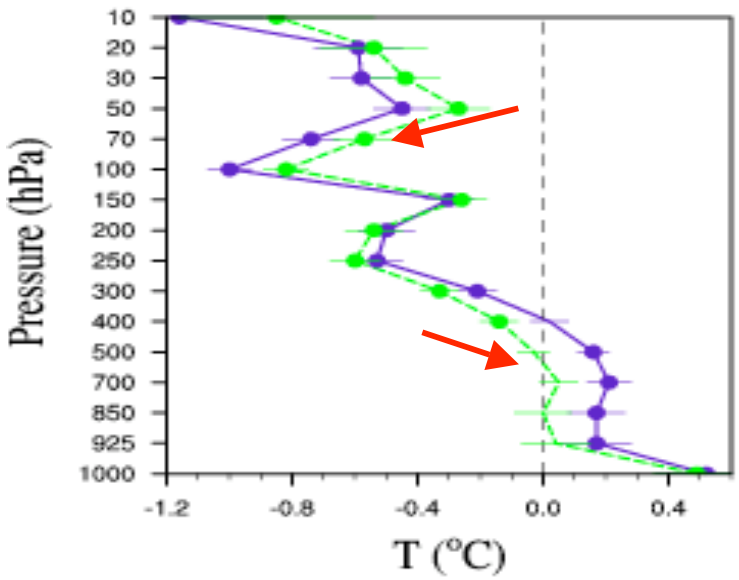
GTS + 10mb top

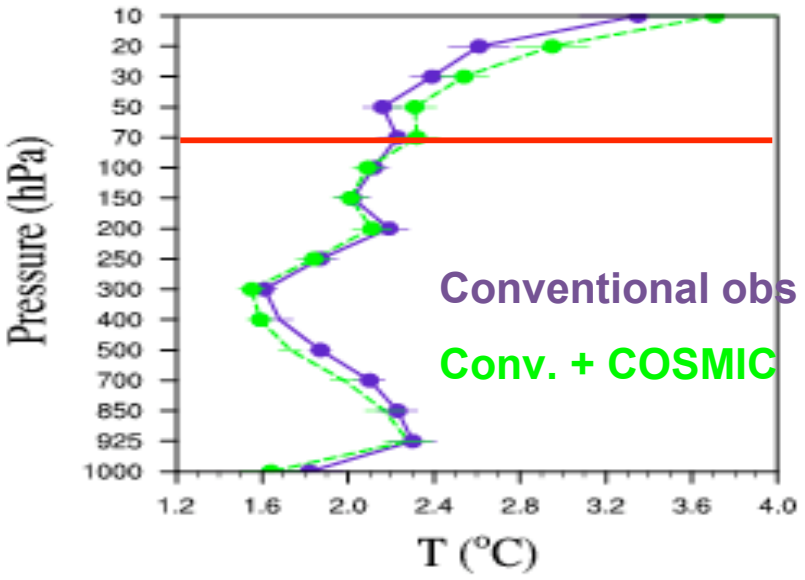


❑ Impact of COSMIC RO Refractivity

(36hr Forecast Verification Against Sondes (O-F))







- Impact of AMSU-A (Supported by NSF-OPP)

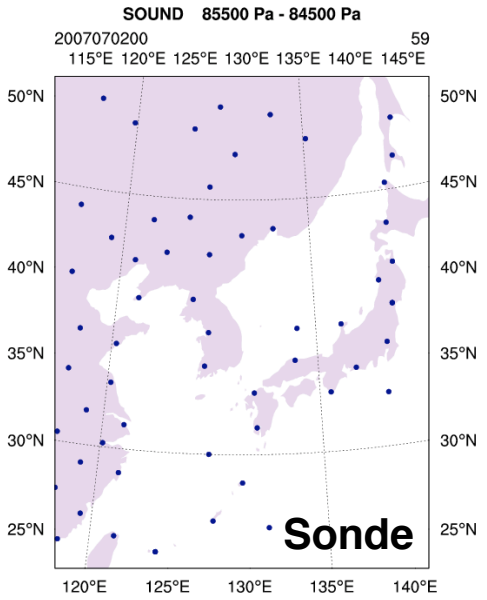
  See **Session 5: WRF Data Assimilation - P5.4 Hui Shao, etc.**

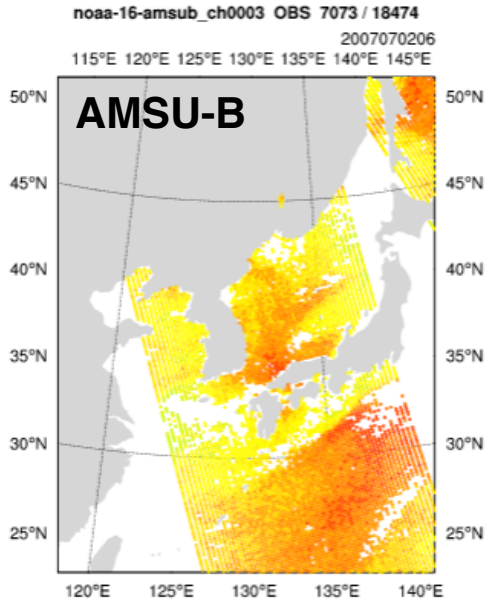
- Testing and tuning of AIRS DA (Supported by NASA)

  See **Session 5: WRF Data Assimilation - 5.3 Thomas Auligne, etc.**

DATC AFWA Testbed:
East Asia Domain (T46)

- **Model**: WRF-ARW, 3D-VAR
- **Namelist**:
  162*212*42L, 15km, 90S time step,
  50mb model top
- **Period**:
  1 ~ 30 July 2007
- **Experiments**: Full cycling
  GTS+AMSU vs. GTS
- **Radiance Data**:
  - NOAA-15/16
  - Data over water
  - AMSU-A: channels 5~9 (T sensitive)
  - AMSU-B: channels 3~5 (Q sensitive)
  - Thinned to 120km
  - +-2h time window
  - Bias Correction (H&K, 2001)

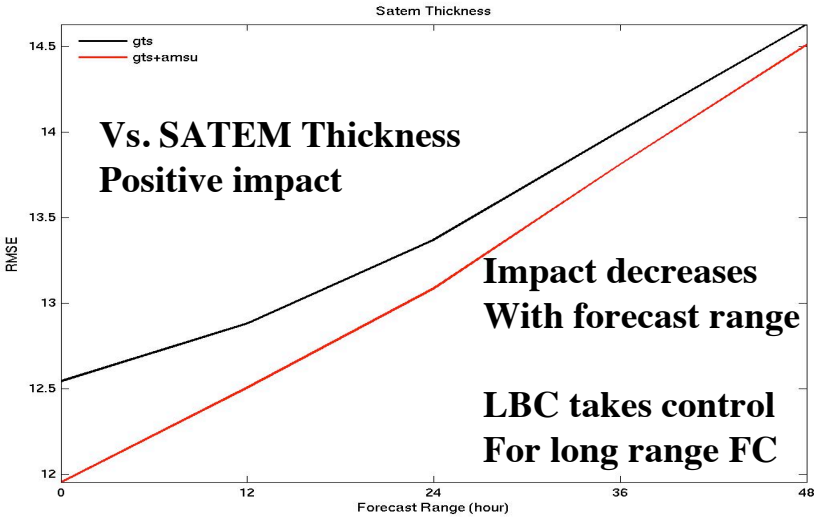


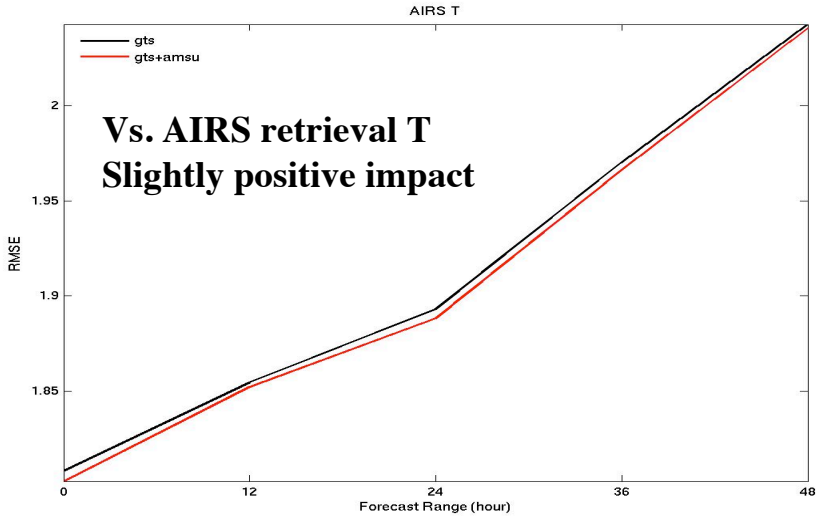


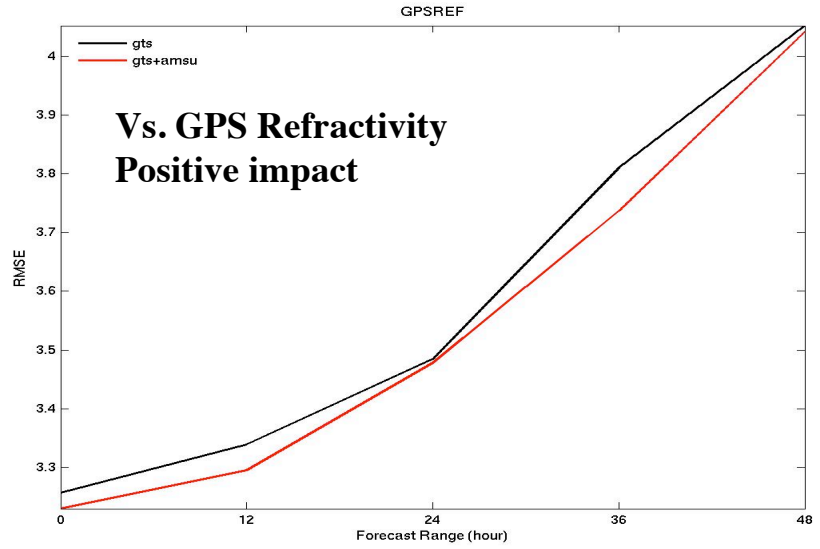
Impact of AMSU Radiance in T46 (from Z.-Q. Liu)

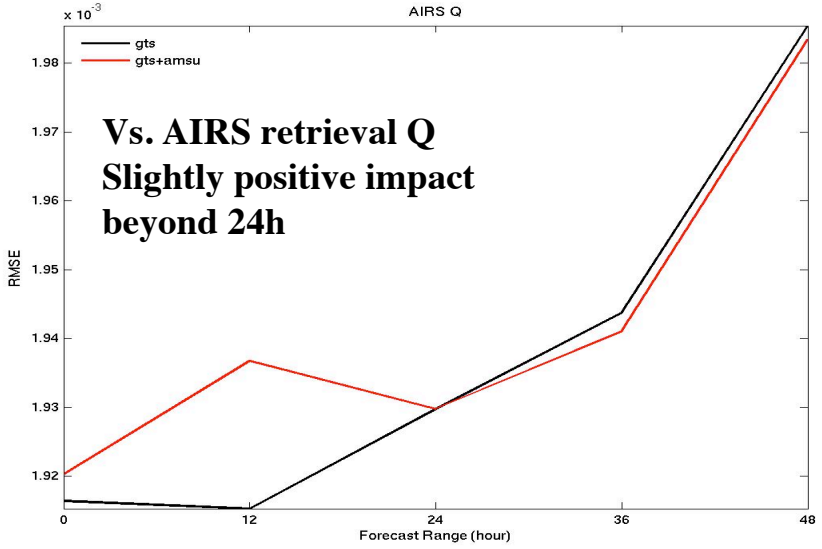
(Verified against unassimilated obs)

See Session 5-P5.1 Z.-Q. Liu etc.

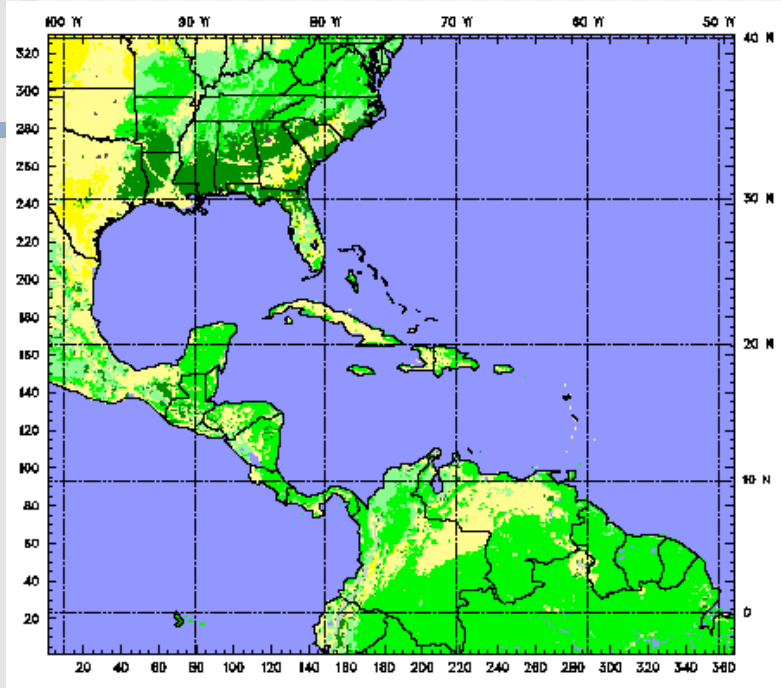






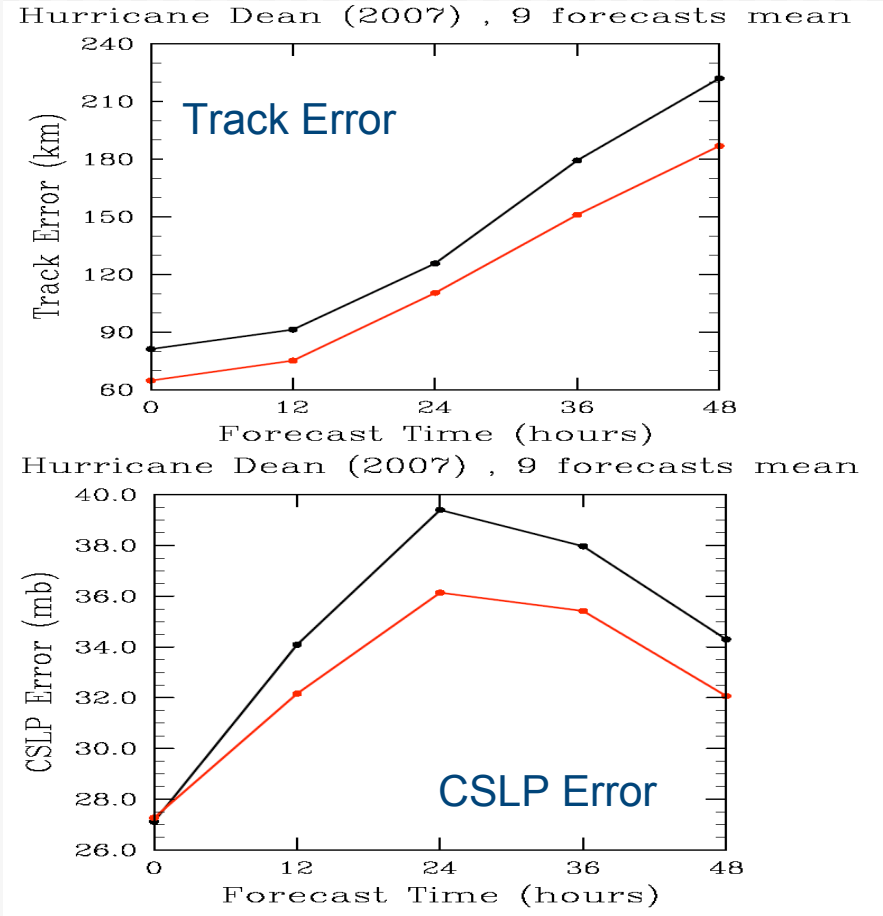


DATC AFWA Testbed: Atlantic Domain (T8)



- **Model**: WRF-ARW, 3D-VAR
- **Namelist**:
  361*325*57L, 15km, 10mb model top
- **Period**:
  15 ~ 20 August 2007
- **Experiments**: Full cycling
  GTS+RADIANCE vs. GTS

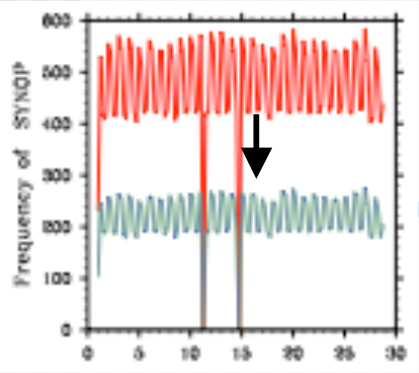
Forecast Error for Hurricane Dean



(From Z.-Q. Liu)

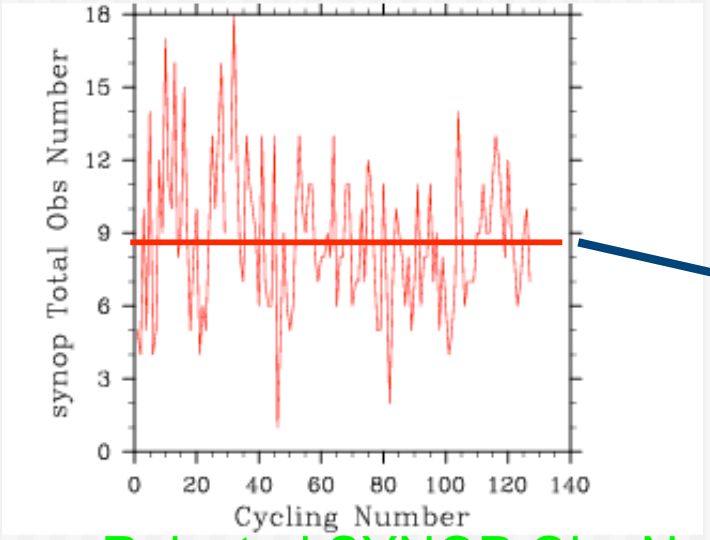
Application of WRF-Var outloop on data rejection

(From Syed Rizvi)

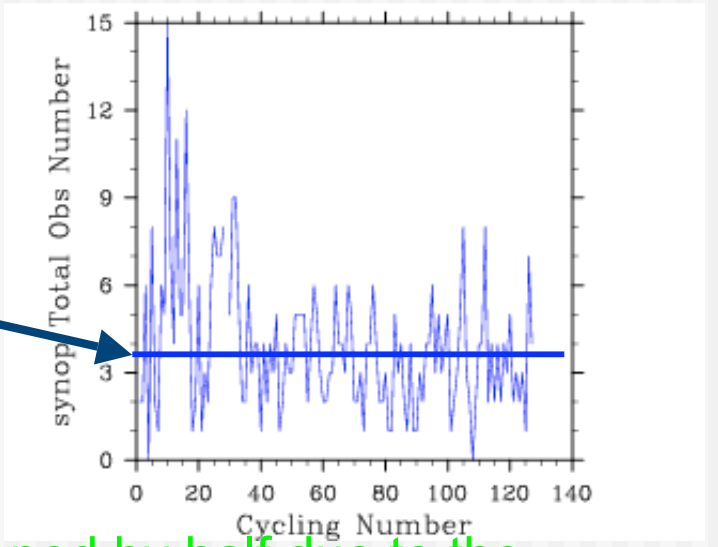


In AMPS, 60% SYNOP obs were rejected by WRF-VAR QC.

Outloop 1



Outloop 2



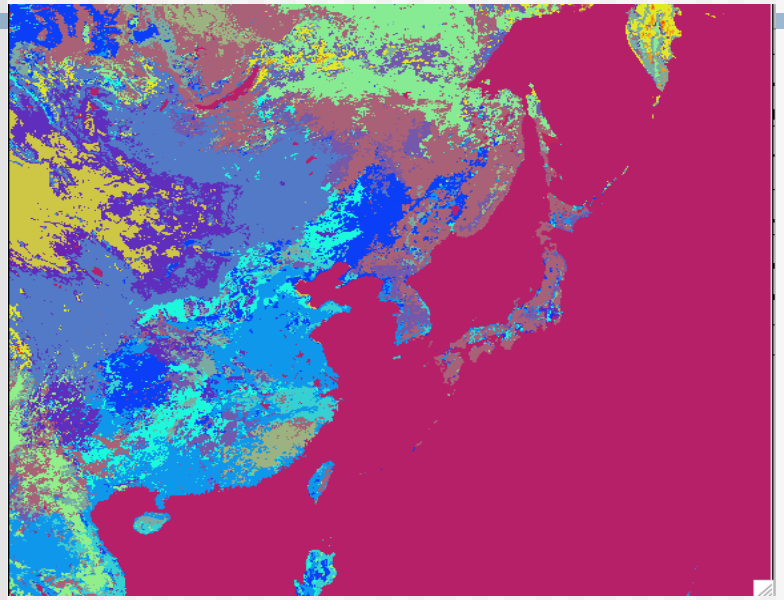
Rejected SYNOP Obs Number dropped by half due to the background update within the second outloop.

See Session 5: WRF Data Assimilation - P5.3 Syed Rizvi, etc.

DATC KMA Testbed

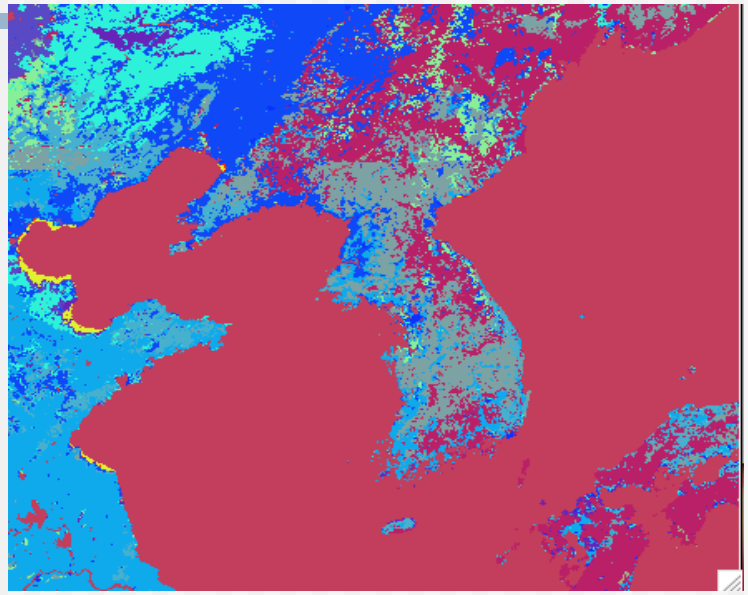
(From Meral Demirtas)

RDAPS Domain



- Model: WRF-ARW, 3D-Var
- Resolution: 10km
- Time step dt=60s
- Grid points: 574x514x33

HiNWP Domain

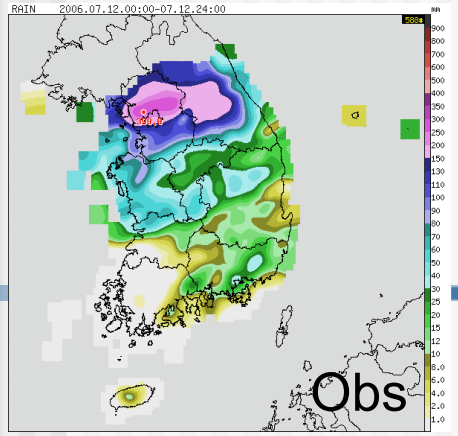


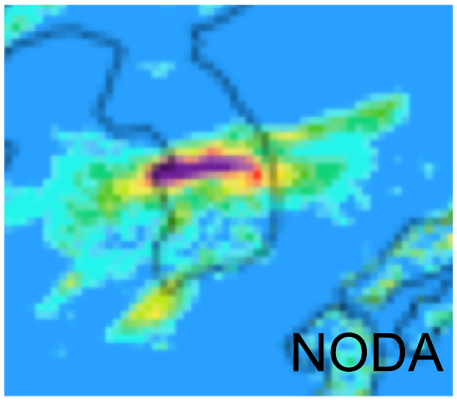
- Model: WRF-ARW, 3D-VAR
- Resolution: 3.33km
- Time step dt=20s
- Grid points: 442x388x33

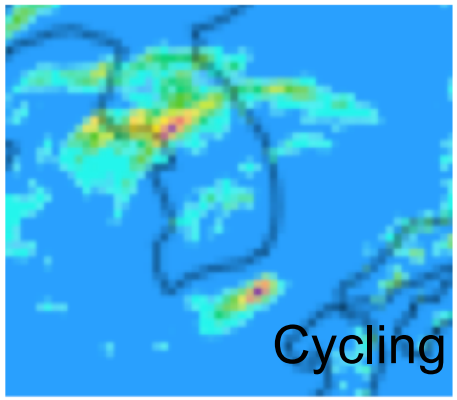
Test period: 1st July - 10th August 2007 (the Changma period)

Testing and evaluation of:
Cycling, radar DA, DA resolution, High-impact weather DA

See Session 5: WRF Data Assimilation - P5.15 Meral Demirtas, etc.

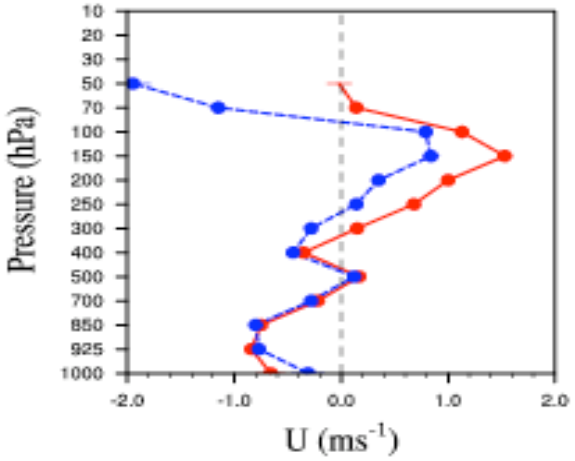


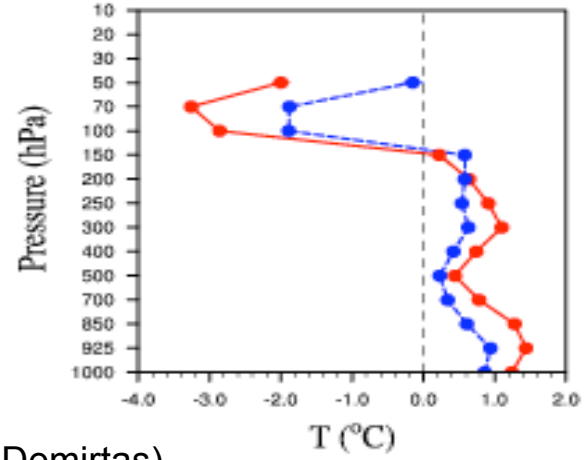




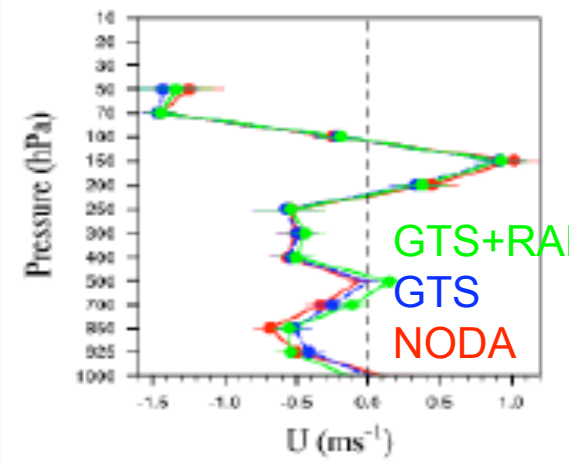
(From Dale Barker & Meral Demirtas)

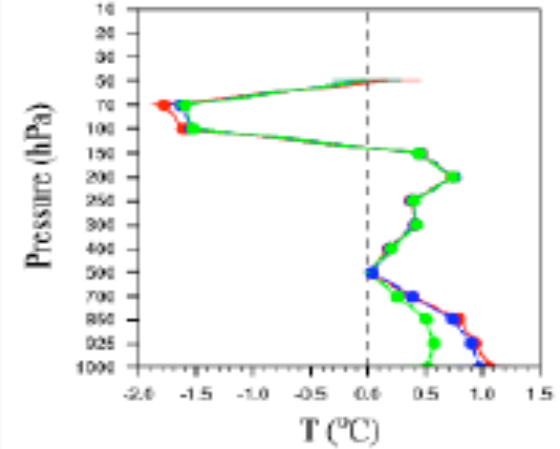
Impact of Cycling vs. NODA





Impact of Radar DA:

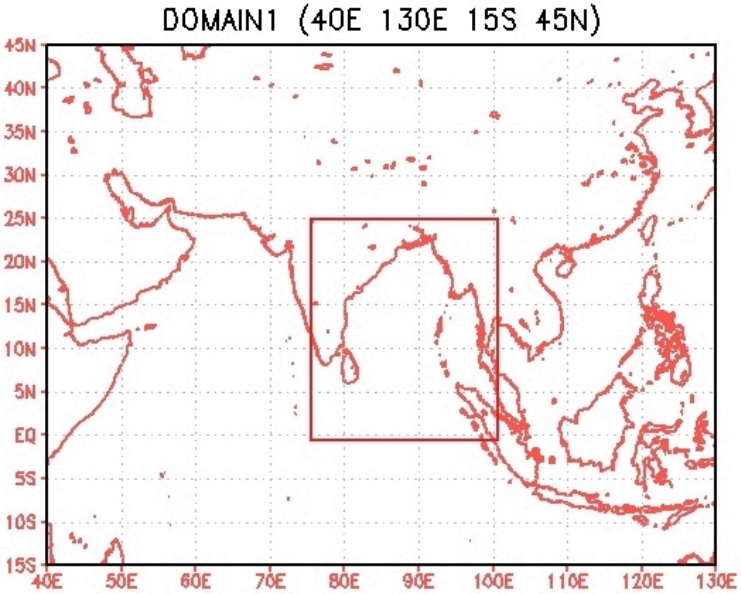




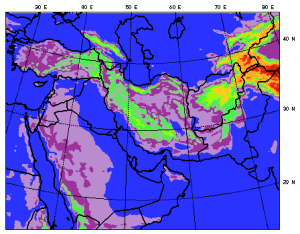
DATC Indian Testbed

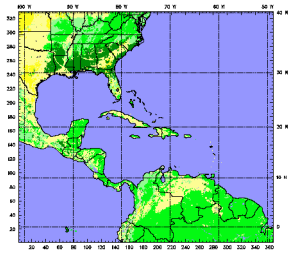
- Model:
  - WRF-NMM, GSI (K. Naga Ratna, IMD)
  - WRF-NMM, WRF-Var (Sujata Pattanayak, IID)

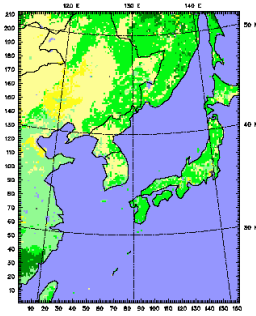
Domain1: 27km
Domain2: 9km
Vertical levels: 51
Ptop: 10hPa
Initial and boundary conditions: FNL
Testing period: Nov. 2007

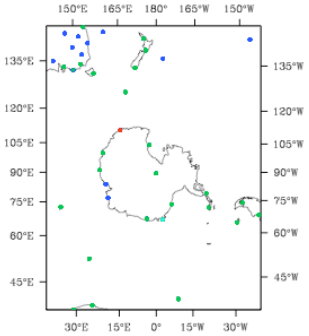


K. Naga Ratna, etc., Session 5 - P5.7
S. Pattanayak, etc., Session 8 - P8.4

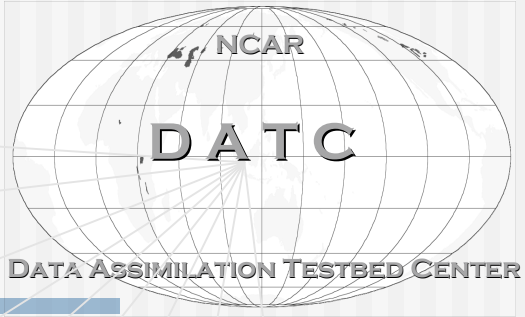








Summary

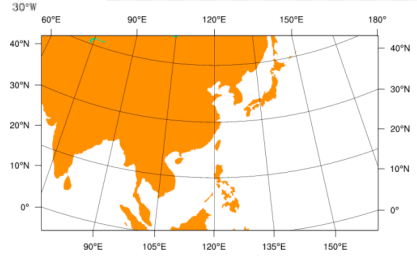


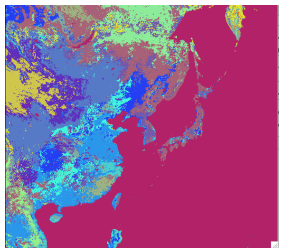
2007 Progress:

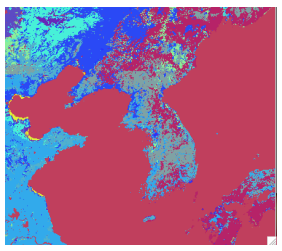
- Expanded to 4 testbeds: AFWA, AMPS, CAA, KMA in ~ 10 domains with various resolutions (3.3 - 60km).
- Observation impacts: COSMIC, Radiances, Radar
- Suite control system has been extended and proven to be robust.
- Successful collaborations with MMM and JCSDA.

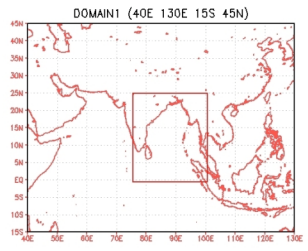
2008 Plans:

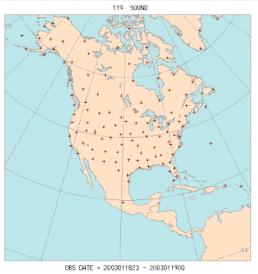
- Observation impacts: Radiances (AMSU, AIRS, SSMI/S), Doppler radar, WindSat/QuickScat.
- Advanced data assimilation: 3/4D-Var, EnKF, Hybrid.
- System Studies: WRF-Var, GSI, DART
- New application: Arctic System Reanalysis
- International visitors











DATC Joint Presentations/Posters

- **5.3 IMPACT OF AIRS OBSERVATIONS OVER THE ANTARCTIC REGION**. **Thomas Auligne**, Hui Shao, Dale Barker, Zhiquan Liu and Hui-Chuan Lin
- **P5.1 RADIANCE DATA ASSIMILATION FOR WRF MODEL: OVERVIEW AND RESULTS.** **Zhiquan Liu**, Tom Auligne, Hui-Chuan Lin, Dale Barker, Xiaoyan Zhang, Xin Zhang, Hui Shao and Xiangyu Huang (NCAR) and Dongliang Wang (Shanghai Typhoon Institute)
- **P5.3 IMPACT OF OUTER LOOP FOR WRF DATA ASSIMILATION SYSTEM (WRFDA).** **Syed Rizvi**, Y.-R Guo, H. Shao, M. Demirtas and X.-Y. Huang
- **P5.4 IMPACT STUDIES OF SATELLITE OBSERVATIONS IN THE ANTARCTIC MESOSCALE PREDICTION SYSTEM: AMSU-A RADIANCE MEASUREMENTS.** **Hui Shao**, Zhiquan Liu, Thomas Auligne, Dale Barker, Jordan Powers and Xiang-Yu Huang
- **P5.7 IMPACT OF THE GSI DATA ASSIMILATION ON WRF- NMM FORECAST OF TROPICAL CYCLONES OVER NORTH INDIAN OCEAN.** **K. Naga Ratna** (India Meteorological Department, India), Ming Hu (NOAA, USA), Xiang-Yu Huang, and S.R.Rizvi (NCAR, USA) and S. Pattnayak (ITT, India)
- **P5.15 HIGH-RESOLUTION SHORT-RANGE NWP OF HIGH-IMPACT WEATHER EVENTS ON THE KOREAN PENINSULA**. **Meral Demirtas**, Dale Barker, Jimy Dudhia, and Dave Gill (NCAR, USA), Ji-Hyun Ha (SNU, S. Korea), Seung-On Hwang (KMA, S. Korea) and Eunha Lim (NCAR, USA)
- **P8.4 A COMPARATIVE STUDY ON PERFORMANCE OF MM5 AND WRF (ARW & NMM) MODELS IN SIMULATION OF TROPICAL CYCLONE OVER BAY OF BENGAL.** **S. Pattanayak** and U. C. Mohanty (ITT, India), S. R. Rizvi, and X. Huang (NCAR, USA) and K. Naga Ratna (India Meteorological Department, India)