Overview on CIMSS GOES-R/JPSS research and applications

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Outlines

• CIMSS overview from Steve Ackerman (Director)

• Current research activities on GOES-R/JPSS science and applications at CIMSS

• One example – study on satellite data assimilation in a regional numerical weather prediction (NWP) model
Symbiotic relationship between CIMSS, SSEC and AOS
CIMSS Mission

- Foster collaborative research among NOAA, NASA, and the University in those aspects of atmospheric and earth system science which exploit the use of satellite technology.

- Serve as a center at which scientists and engineers working on problems of mutual interest may focus on satellite related research in atmospheric studies and earth system science.

- Stimulate the training of scientists and engineers in the disciplines involved in the atmospheric and earth sciences.
CIMSS Core Mission Activities

- Continue NOAA collaborations with GOES and POES programs.
  - GIMPAP – GOES-R, JPSS
- Maintain and expand expertise in hyperspectral observations
  - CrIS, S-HIS, IASI, China’s hyperspectral
- Continue to transition research to operations
  - Many already used in operations
- Continue strong involvement in new satellite missions
  - JPSS, Tropospheric Emissions Monitoring of Pollution (TEMPO), CLARREO
- Continue support of SSEC Data Center
  - Critical for data and satellite checkout
CIMSS Core Mission Activities

- Continue field programs with SSEC
  Rooftop, SPARC, lidar, microwave
- Maintain end-to-end capabilities.
  Collaborations with SSEC make this possible
- Maintain Cal/Val expertise
  GOES check-out, instrument calibrations
- Secure research grants
  Needed to support research to operations
CIMSS Core Mission Activities

- Continue involvement in professional training
  
  SHyMet, VISITView, CIMSS Satellite Blog

- Support graduate students.
  
  Currently 15 grad students funded with CIMSS PIs

- Expand expertise in on-line instruction
  
  Professional development and web-based, MOOC

- Support public outreach and K-12 education
  
  Science on a Sphere, blogs, workshops
2014 CIMSS Personnel (143 Associates)

- Visitors (11)
- Graduate Students (15)
- Undergraduates (9)
- Admin (5)
- PI (28)
- NOAA (9)
- Others Sites (5)
- Research Staff (65)
CIMSS graduate students
Themes

- Satellite Meteorology Research and Applications
- Satellite Sensors and Techniques
- Environmental Models and Data Assimilation
- Outreach and Education

...set forth in the 2009 re-competition for the CIMSS
CIMSS current ongoing research projects

- Algorithm science for new generation of NOAA satellites (NPP/JPSS and GOES-R series) – algorithm development, calibration, validation, and re-processing
- Proving Ground and Risk Reduction (PGRR) – Exploring new algorithms, new products, new applications, user readiness
- Direct broadcast (DB) software for regional real time applications of both POES/GOES data
- Visualization – McIDAS-X/McIDAS-V
Science Examples
Science Highlights

algorithms

INFORMATION

theory
modeling

KNOWLEDGE

applications

new instruments

Tobin
VIIRS cloud typing

Tobin

new instruments
GOES-R (water vapor) and LEO (sounding) assimilation for HIW forecasts – A demonstration system based on WRF/GSI

Data preparation:
- GDAS/GFS data
- Conventional obs data
- Radiance obs data
- JPSS and other satellite DP data
- Bufr conversion
- CIMSS SFOV rtv (AIRS/CrIMSS)
- IMAPP/CSPP data transfer
- GOES-R standard DP (soundings, tpw, winds)

Analysis and forecast:
- GSI/WRF Background & boundary preprocessing
- GSI background at time t-6 hrs
- GSI analysis at time t-6 hrs
- WRF 6 hours forecast
- GSI background at time t
- GSI analysis at time t
- WRF 72 hours final forecast
- WRF postprocessing
- Diagnosis, plotting and validation
- Data archive

Li team

algorithms

new instruments

DATA

ACTION

applications
GOES-R (water vapor) and LEO (sounding) assimilation for HIW forecasts – A demonstration system based on WRF/GSI

Jun et al
Science Highlights

![Diagram](image)
Science Highlights

algorithms

new

Cintineo

theory

modeling
Science Highlights
Science Highlights
One example: satellite data assimilation in a regional NWP model for research and applications

- Better cloud detection for both infrared (IR) and microwave (MW) radiance assimilation
- IR radiance assimilation in cloudy skies
Satellite Data Assimilation for Tropical storms (SDAT) (http://cimss.ssec.wisc.edu/sdat)

Research Path

WRF Assimilation at SSEC
Using TPW from MODIS/VIIRS LEO Sounder Profiles, and AMVs

Hurricane Forecast Improvement

Research testbed for improving the utilization of GOES-R/JPSS data (Sounder, ABI, AMVs, Clouds)

R2O Research

Operational NWP

Refining the Operational Path

End Users (NHC, Local Forecasters)
Some ongoing methodologies for assimilating IR radiances in cloudy skies

• Using radiances only from clear fields-of-view (FOVs)
• Using channels not affected by clouds (detection of clear channels is also challenging);
• Direct assimilation of cloudy radiances using RTM;
• Alternative approach for assimilating thermodynamic information
  – Cloud-clearing using background (EMC);
  – MW/IR sounder cloud-clearing (Chris Barnet)
  – IR imager/sounder cloud-clearing (keep single field-of-view spatial resolution for regional NWP applications)
Using cloud-cleared radiances for assimilation

- Data in cloudy regions according to MODIS cloud mask are assimilated as clear-sky in GSI, which contains cloud contamination.
- Cloud-clearing method generates clear equivalent radiances for assimilation in partially cloudy regions.
- Cloud-cleared radiances removes the cloud contamination and provides more clear equivalent radiances.

Li et al. 2004 - JAMC;
Li et al. 2005 – IEEE TGARS
Wang et al. 2014 – GRL
Wang et al. 2015 - JGR
Impact of assimilating cloud-cleared radiances on forecasts

- The RMSE of the hurricane track from AIRS (MOD cld-clr) is the smallest among the three experiments for the whole process, especially after the 18-hour forecasts.

- The RMSE of the hurricane track from AIRS (MOD cld-clr) is around 10 km to 25 km smaller than that from AIRS (MOD clr), and is around 10 km to 50 km smaller than that from AIRS (GSI clr).

- For the maximum wind speed, the three experiments have comparable results, making it difficult to determine which is better experiment. So it is neutral for the three experiments.
MW sounder sub-pixel cloud characterization (see poster 1-48) with collocated imager cloud products
- ATMS/VIIRS onboard NPP
- AMSU-A/MODIS onboard Aqua

GSI v3.0, v3.3: 3-Dvar Data Assimilation Method
- NAM background error covariance matrix
- Cycled bias correction
- Conventional Data – from GTS
- Satellite radiances: ATMS/NPP, AMSU-A/Aqua

Hurricane Sandy
- Assimilation: Oct 25 06z to Oct 27 00z, 2012
- Forecasts: Oct 25 06 to Oct 30 00z, 2012
- Assimilation every 6 hour
- Assimilation window: 90 min

GOES-13 10.7 μm

(1) ATMS (solid lines) is better than Aqua/AMSU-A (dashed lines) for Hurricane Sandy (2012 forecasts;
(2) MW sounder sub-footprint cloud characterization with imager cloud products (blue lines) improves GSI
precipitating cloud detection (red lines) for radiance assimilation, which has the potential for operational use.

72 hour track forecasts started at 18 UTC, 26 Oct

Hurricane Sandy (2012) forecast RMSE from 8 groups.
Summary

• CIMSS is actively involved in GOES-R/JPSS science and applications

• Some CIMSS research progress are in near real time demonstration and applications
  – Tropical cyclone (http://tropic.ssec.wisc.edu/)
  – Satellite blog (http://cimss.ssec.wisc.edu/goes/blog/)
  – GOES real time product (http://cimss.ssec.wisc.edu/goes/rt/)
  – Regional satellite assimilation system (http://cimss.ssec.wisc.edu/sdat/)
  – CIMSS WRF-CHEM aerosol forecasting (http://raqms.ssec.wisc.edu/)

• CIMSS has also developed satellite data application software packages for national and international users
  – CSPP (Community Satellite Processing Package)
  – IAPP (International ATOVS Processing Package)
  – IMAPP (International MODIS/AIRS Processing Package)
  – McIDAS (Man computer Interactive Data Access System)
  – Polar Remote Sensing Software
  – VISITview