Progress on the assimilation of advanced IR sounder radiances in cloudy skies

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Motivation

• How does “clear location” detection impact IR radiance assimilation? And

• How to improve clear location detection for IR radiance assimilation?

• Direct assimilation of cloudy IR radiances in NWP is still challenging, any alternative solutions for IR radiance assimilation in cloudy regions?
CrIS clear radiance locations (GSI)
channel 96 (wavelength 709.375 cm\(^{-1}\))

Oct 25 18z

IASI clear radiance locations (GSI)
channel 259 (wavelength 709.5 cm\(^{-1}\))

Oct 26 00z
Near real time Satellite Data Assimilation for Tropical storms (SDAT)  
(http://cimss.ssec.wisc.edu/sdat)  
(11P.03 “A near real time regional satellite data assimilation system for high impact weather studies”)

WRF-ARW v3.2.1: 12 km horizontal resolution 
(400*350) , 52 vertical layers from surface to 10hPa

GSI v3.3: 3D-Var Data Assimilation Method
• NAM background error covariance matrix
• Cycled bias correction
• Conventional Data (GTS)
• AMUS-A radiances onboard NOAA-15, NOAA-18, Metop-A, and Aqua
• CrIS radiances onboard Suomi-NPP

Hurricane Sandy
• Assimilation : Oct 25 06z to Oct 27 00z, 2012
• Forecasts: Oct 25 06z to Oct 30 00z, 2012
• Assimilation every 6 hour, 8 groups in statistics

CrIS spectrum (black) and the corresponding 399 channels (blue dots) selected for the NWP center.
Q1: How does clear location detection affect IR radiance assimilation?


CrIS channel 71, 693.75 cm\(^{-1}\)

CrIS clear location from GSI

CrIS clear location from VIIRS

CrIS clear locations (green) overlaying on GOES-13 11 µm BT (B/W)

CrIS CCRs from Chris Barnet
Hurricane Sandy (2012)

Using AIRS with MODIS for clear location detection shows similar improved impact.

Wang et al. 2014 (GRL)

72-hour forecasts of Sandy from 06z 28 to 00z 30 Oct, 2012
Q3: Direct assimilation of IR cloudy radiances is desired, but quite challenging, any alternative solution on IR radiance assimilation in cloudy region?

Cloud-cleared radiances (CCRs): clear equivalent radiances from partly cloud cover FOV after cloud effect is removed using additional information.

Currently three are types of CCRs:
(1) Imager-based
(2) Microwave-based
(3) Background-based

AIRS data locations at 18z 25, Oct 2012

Imager-based CCRs

Wang et al. 2015 - JGR
Impact of assimilating CCRs (imager-based) on temperature forecasts – RMSE against RAOBs

Pressure (hPa)

T-RMSE (K)  T-RMSE (K)  T-RMSE (K)

24-hour  48-hour  72-hour

AMSUA from NOAA-15, -18, Aqua and Metop-A

Wang et al. 2015 (JGR)
Impact of assimilating AIRS CCRs (MODIS-based) on hurricane Sandy track forecasts

Hurricane Sandy (2012) forecast RMSE

Wang et al. 2015 – JGR

AMSU-A from NOAA-15, -18, Aqua, Metop-A
DA Experiments on Hurricane Joaquin (2015)

WRF-ARW v3.6.1: 12 km horizontal resolution (480*380), 52 vertical layers from surface to 10hPa

GSI v3.3: 3D-Var Data Assimilation Method
- NAM background error covariance matrix
- Cycled bias correction
- Conventional Data (GTS)
- AMUS-A radiances from NOAA-15, NOAA-18, NOAA-19, and Metop-A
- CrIS radiances from Suomi-NPP

Hurricane Joaquin (2015)
- Assimilation: Sep 30 00z to Oct 01 18z, 2015
- Forecasts: Sep 30 00z to Oct 04 18z, 2015
- Assimilation every 6 hour, 8 groups in statistics
8 groups of forecasts in the RMSE statistics

AMSUA from NOAA-15, -18, -19, and Metop-A
Summary

• Clear location detection has substantial impact on IR radiance assimilation, collocated imager cloud mask can improve the detection of clear location for IR radiance assimilation;

• Imager-based clear-cleared radiances (CCRs) provide value-added impact, could be an alternative approach for radiance assimilation in some cloudy skies;

• Future work
  – comparisons among CrIS CCRs (imager-based, BG-based and MW-based), CCR impact studies;
  – clear location from collocated imager plus clear channels in cloudy regions for IR radiance assimilation.