

### Assimilation of Reconstructed Radiances from IASI and CrIS Principal Component Scores

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### Motivation



- Work by Cristina Lupu at ECMWF showed they saw no ill effects when the switched to using PC scores
- Wanted to try in GEOS-ADAS to prepare for instruments like MTG-IRS and GeoXo where PC scores will be used
- \*spoiler\*: also not sure cloud detection/bias correction would be as forgiving as CADS vs minimum residual method in GEOS



### **Principal Component Scores**

Lots of Spectra Derive Eigenvectors Principal Component Eigenvectors (E) Noise Normalization Matrix (N)

Compression Decompression Operator

Compression

 $p = E^T N^{-1} (y - \overline{y})$ 



- Steps 1 & 2 are performed by the distribution center, Step 3 is the data user's pr
- Omitting a few extra steps depending on product like BUFR formatting, apodizat product is unapodized, etc. (time spent implementing not proportional to talk contents)

### First IASI PCS Experiment





- Make no modifications to the DAS, only difference is replacing the data source to use reconstructed radiances (replace Metop B & C IASI radiances)
- 1 May 2022 30 June 2022 (61 days)
- Generally Neutral Impact except for 850 hPa

- ▲ far better, significant (99.99% confidence)
- ightarrow better, significant (99% confidence)
- 🔅 slightly better, significant (95% confidence)
- no significant difference
- slightly worse, significant (95% c nfide ce)
- ▽ worse, significant (99% conf
- ▼ far worse, significant (99.99% c fidency)

## **Cloud Detection Problem**

- GSI minimum residual method relies on normalization of by the expected "noise" ~Eyre and Menzel, 1998
- PC compression effectively "drops" noise making it less noisy
- Using the original noise estimate results in cutting off cold end of distribution on surface channels, causing the bias to shift positive, results in a feedback



### Adjustment Helps, but still...

- The modification to cloud detection helps, but still some degradation
- Seems a bit weird for surface sensitive channels to that much of an impact on near surface Q

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- △ better, significant (99% confidence)
- 🔅 slightly better, significant (95% confidence)
- no significant difference
- slightly worse, significant (95% confidence)
- $\nabla$  worse, significant (99% confidence)
- ▼ far worse, significant (99.99% confidence)

	Т	ropics	
Variable	Pressure Level	COR	RMS
Forecast	Day	12345	12345
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	70		
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Height	250		
Height	500		
	700	8	8
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SLP	1000		
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Specific	250	8	8
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w/o cloud detection Modification

w/ cloud detection Modification



### Trying CrIS PC scores NOAA 20



- Same Story as IASI, but just about as bad for replacing 1 CrIS on N20 as for 2 IASI's on Metop B & C
- Go through exercise of modifying cloud detection, but can't improve it.
- Weird! Something else going on here/broken with the system?

## What's going on here?



- Results up to this point with a system that had known issues with all-sky microwave bias correction
- Updated system also includes a model update which improved near surface water vapor forecasts
- Current untested hypothesis slight variations in IR channel counts/bias correction modulating Microwave bias correction, causing degradation
- Now for a "Re-Do" for CrIS N20 PC scores (haven't done IASI, yet) ....
- Mid-July through Mid September 2023 (~60 days)



#### Still need to modify cloud detection to bring counts

up...



CrIS-FSR N20 Count Used QC Start: 2023-07-16T12Z End: 2023-09-16T18Z





- Repeat two experiments one with no modification to cloud detection, other the same cloud detection modification previously
- Possibly could "loosen" cloud detection a little bit more

#### Forecast Scores w/o Cloud Detection Modification



Northern Hemisphere				Southern Hemisphere				Tropics			
Variable	Pressure Level	COR	RMS	Variable	Pressure Level	COR	RMS	Variable	Pressure Level	COR	RMS
Forecast	Day	12345	12345	Forecast	Day	12345	12345	Forecast	Day	12345	12345
Geopotential Height	10 70 250 500 700 850			Geopotential Height	10 70 250 500 700 850			Geopotential Height	10 70 250 500 700 850		
	1000 10 70				1000 10 70			SLP	1000 10 70		
Specific Humidity	100 250 500 700 850			Specific Humidity	100 250 500 700 850			Specific Humidity	100 250 500 700 850		
Temperature	10 70 250 500 700 850			Temperature	10 70 250 500 700 850			Temperature	10 70 250 500 700 850		**
U-Wind	10 70 250 500 700 850			U-Wind	10 70 100 250 500 700 850			U-Wind	10 70 100 250 500 700 850		8 8 82 8 832 8
V-Wind	10 70 100 250 500 700 850			V-Wind	10 70 100 250 500 700 850			V-Wind	10 70 250 500 700 850		

- Much better result, even modest improvement of Q and 700 hPa in SH and Tropics
- Some degradation NH Geopotential Height and SLP



#### Forecast Scores w/ Cloud Detection Modification



	Northern	Hemisphere	•		Southern	n Hemisphere	)	Tropics			
Variable	Pressure Level	COR	RMS	Variable	Pressure Level	COR	RMS	Variable	Pressure Level	COR	RMS
Forecast	Day	12345	12345	Forecast	Day	12345	12345	Forecast	Day	12345	12345
	10		8	Geopotential Height	10	*	$\bigtriangledown$	Geopotential Height	10		
	70				70		88 8		70		
Geopotential	100				100		$\bigtriangledown$		100		
Height	250				250	888			250		
5	500				500				500		
	700				700				700	8	
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SLP	1001			SLP	1000			SLP	1000	·····	
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Humidity	500			Humidity	500				500	Δ	
	700				700				700		
	850				850				850		
	10			Temperature	10	8	8	Temperature	10		
	70				70	8			70		
	100				100		888		100	Δ	$\triangle$
Temperature	250		*		250	$\nabla$			250	$\square$	
	500				500	*	$\square$		500		
	700				700				700	Δ	$\triangle$
	850				850	8	$\bigtriangleup$		850	8	
				U-Wind	10	8	8	U-Wind V-Wind	10		
	100	8	8		70		8		70		
U-Wind	250				100	$\triangle$			100		
	230				250		8		250		
	700				300				700	20 20	
V-Wind	850				700				850		
	10				10				10		
	70				70		8		70		
	100				100	8			100		
	250				250	8	<u></u>		250		
	500				500		· · ·		500		
	700				700	888	888		700	38 - 388	
	850				850				850		

- Improved Q at 700 hPa in the tropics
- Geopotential Height degradation removed in NH
- Some degradation in SLP in NH remains
- Expecting neutral, but neutral to positive  $\rightarrow$  won't complain!

#### **Observations Fit IASI-Metop-C**



IASI METOP-C Count Used QC Start: 2023-07-16T12Z End: 2023-09-16T18Z

IASI METOP-C Standard Deviation O-B Start: 2023-07-16T12Z End: 2023-09-16T18Z



- More Observations pass QC for both cases, but w/ cloud detection has more
- Hit/Miss with standard deviations, but w/ cloud detection modification generally speaking improved, relative to w/o cloud detection modification
- Changes here possibly not statistically significant

### **Observations Fit ATMS NOAA 20**



#### ATMS N20 Count Used QC Start: 2023-07-16T12Z End: 2023-09-16T18Z

ATMS N20 Standard Deviation O-B Start: 2023-07-16T12Z End: 2023-09-16T18Z



- More Observations pass QC for both cases looking at water vapor channels
- Also more pass QC for 5&6 w/ cloud detection mod
- Generally speaking w/ Cloud modification has improved standard deviation, and converse integly relative to w/o cloud modification (changes here possibly not statistically significant)

# Experiments with CrIS PC scores using updated system Increments (no cloud detection modification)



#### Experiments with CrIS PC scores using updated system Increments (with cloud detection modification)



#### Next Steps/Conclusions/Future Areas



- Run experiment with using Desroziers or Desroziers-like estimate based upon reconstructed radiances → pretend we're assimilating a "new instrument"
- Prepare for assimilation of MTG-IRS → use sample data set to establish plumbing
- PCA reconstructed radiances should be readily assimilated with some modifications to cloud detection
- Using CADS (Eumetsat/NWPSAF cloud detection) which ECMWF uses has been added to EMC GSI, and coming to JEDI → potential benefits to reducing bias correction/cloud detection feedback

