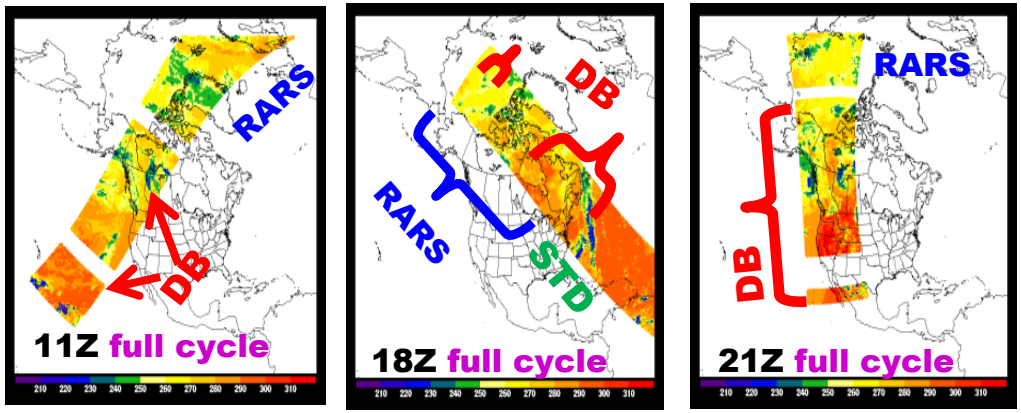


Sample CrIS data swaths from different feeds (standard feed, RARS feed, direct broadcast)

Impact of HSIR and Direct Broadcast Data on Regional Modeling

Presented to CGMS-48 Plenary, Session : HSIR observations, Agenda item 4.1

Coordination Group for Meteorological Satellites

A47.10 Plenary: CGMSSEC together with CMA to organize a thematic session at CGMS-48 on hyperspectral sounding observations

- **NOAA/NESDIS and NOAA/OAR have collaborated on demonstration of use of direct broadcast sounder data in NOAA regional hourly updating forecast models.**

- **The reduced latency for the direct broadcast data is critical for the hourly updating models resulting in significant positive forecast impacts and use of the direct broadcast data has been operational since 2018.**

- **CrIS hyperspectral IR data are used in the RAP data assimilation system, as well as IASI and AIRS data. CrIS data are also used for model forecast verification.**

Agenda

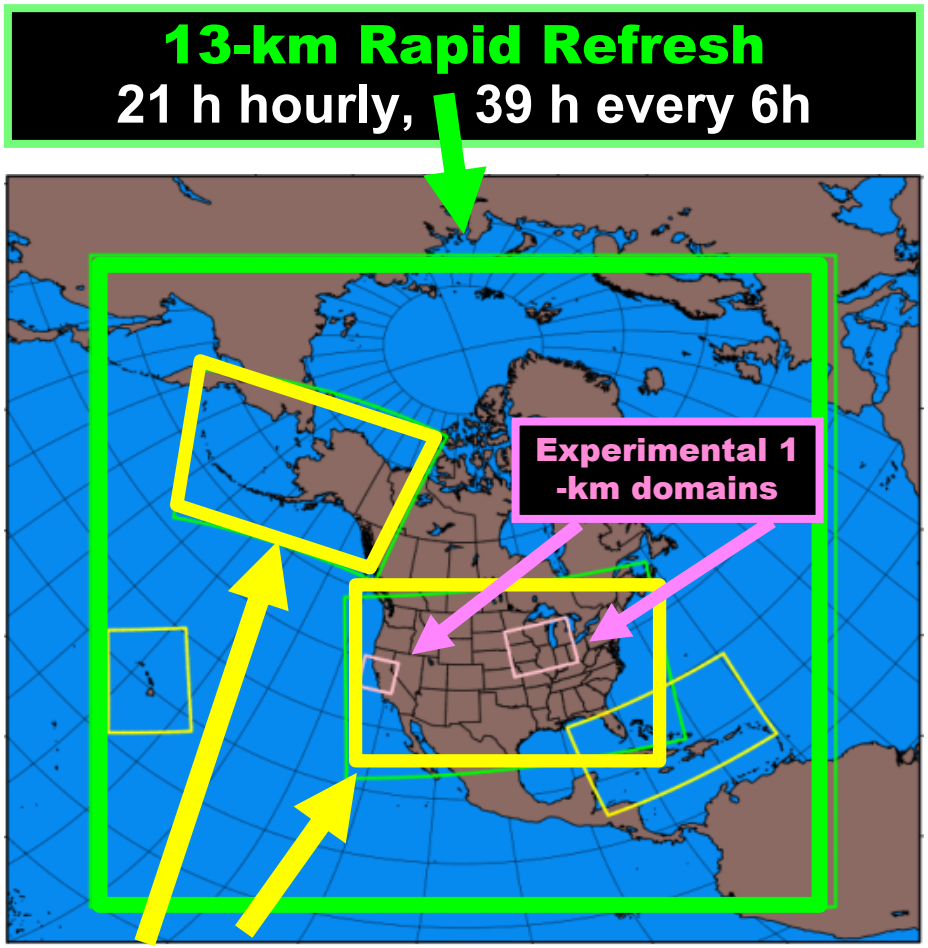
- Discuss impact of sounder data to regional models
- Examine importance of hyperspectral IR radiances for validating regional model impacts
- Highlight the importance of low latency
- Respond to NOAA Direct Broadcast demo to evaluate impact of DB data on NWP regional models.

NOAA operational hourly updating regional models

Rapid Refresh (RAP)

High Resolution Rapid Refresh (HRRR)

- Provide guidance for localized weather hazards:
  - *convection / severe storms*
  - *winter storm details*
  - *icing, turbulence*
  - *low clouds and fog*
- Users communities include:
  - *general forecasters*
  - *severe weather*
  - *aviation*
  - *renewable energy*



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Increasing use of radiance data in RAP model

- **AMSU-A**
  - R • NOAA_n15: channels 1-5, 7-10, 15;
  - R • NOAA_n18: channels 1-10,15; (removed channels 5, 8)
  - R • NOAA_n19: channels 1-9,10, 15; (removed channel 7)
  - R • METOP-a: channels 1-6, 9,10,15;
  - R • METOP-b: channels 1-10,15; (removed channels 1-7, 15)
  - AQUA: channels 6, 8-10; (remove channel 6)
- **MHS**
  - R • NOAA_n18, METOP-A, and METOP-B:1-5
  - R • NOAA-19: 1-5 (removed channel 3)
- **GOES:** GOES-15 (sndrD1,sndrD2,sndrD3,sndrD4): channels 3-8, 10-15
- **SEVIRI**: channels 5,6 from M10
- DR • **ATMS**: channels 1-11, 16-22 from S-NPP
- DR • **CrIS-NSR**: 66 channels from S-NPP (replaced by CrIS-FSR)
- **SSMIS** : channels 1-2, 5-7 from DMSP-17 (removed channel 2)
- **AIRS**: 66 channels from AQUA
- DR • **IASI**: 98 channels (longwave) from METOP-A and METOP-B
- DR • **CrIS-FSR**: 72 channels from S-NPP and NOAA-20
- DR • **ATMS**: channels 1-11, 16-22 from NOAA-20
- **ABI** : three water vapor channels (channels 8-10) from GOES-16

RAPv3 / earlier
RAPv4 (2018)
RAPv5 (2020)

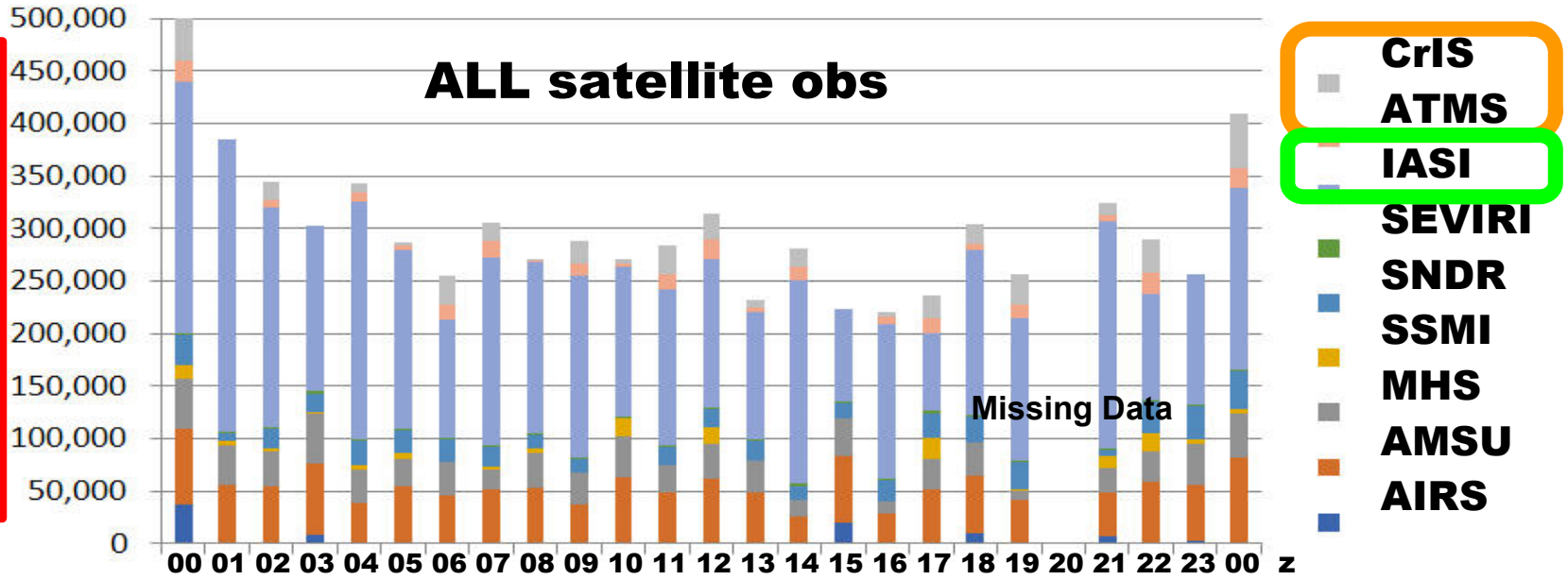
D = DB = Direct Broadcast

R = RARS = Regional ATOVs Retrans-mission Service

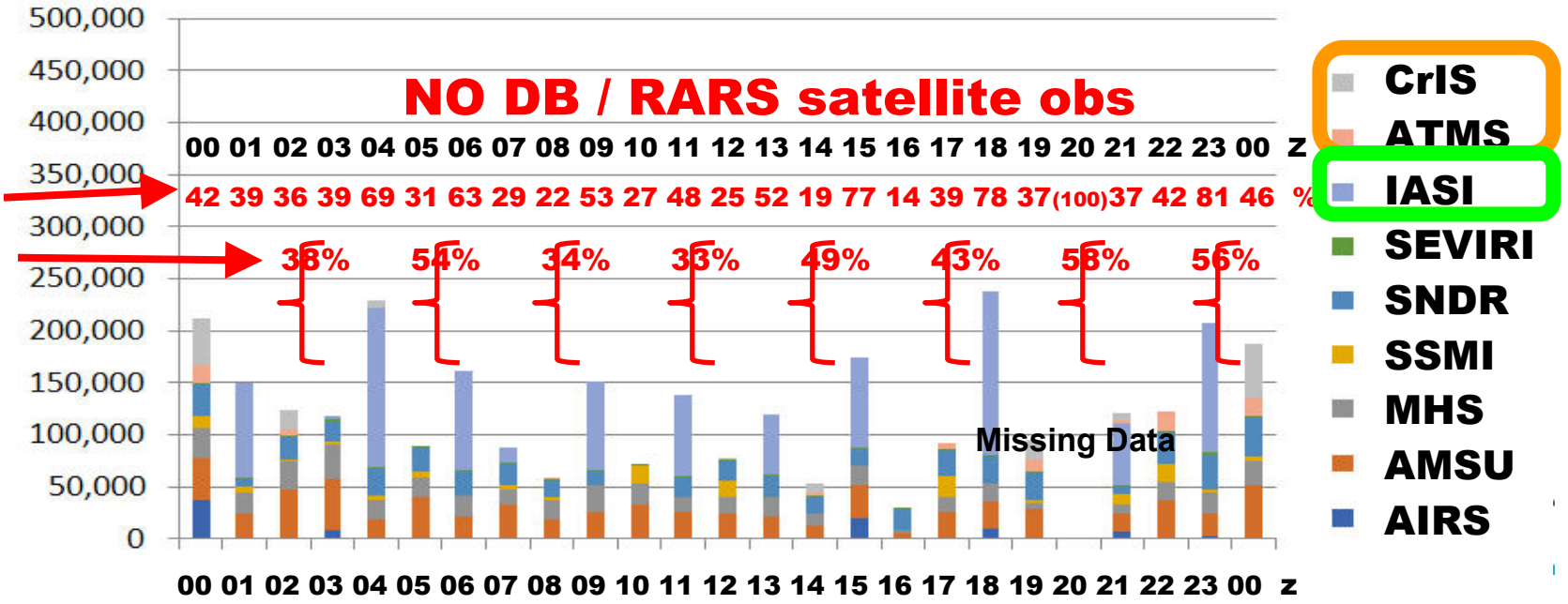
Coordination Group for Meteorological Satellites

Sample hourly radiance data counts

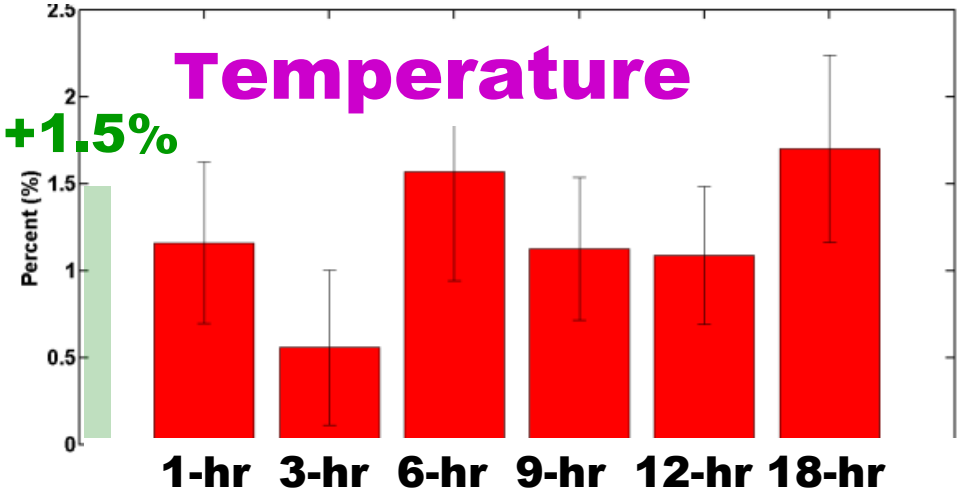
Direct Broadcast Data feed extremely important for hourly updating (~ 25 min. data cutoff)

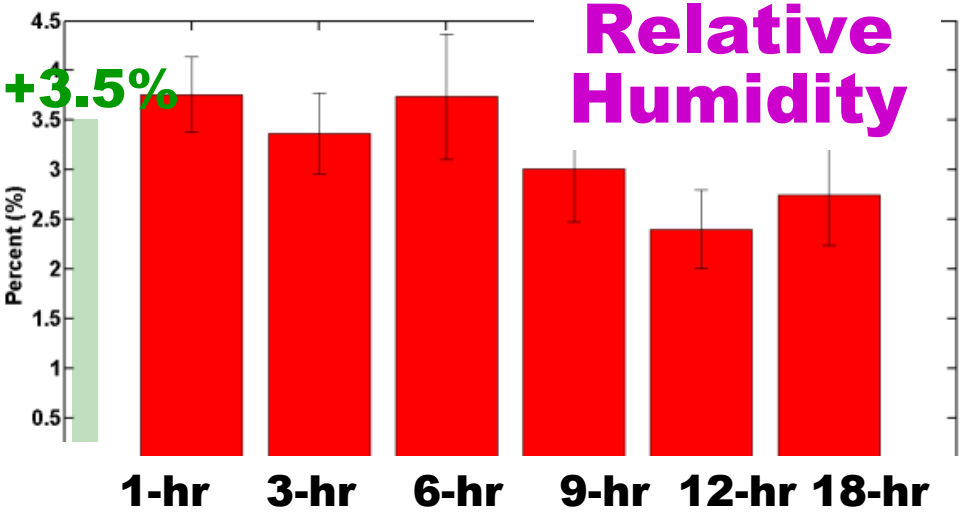


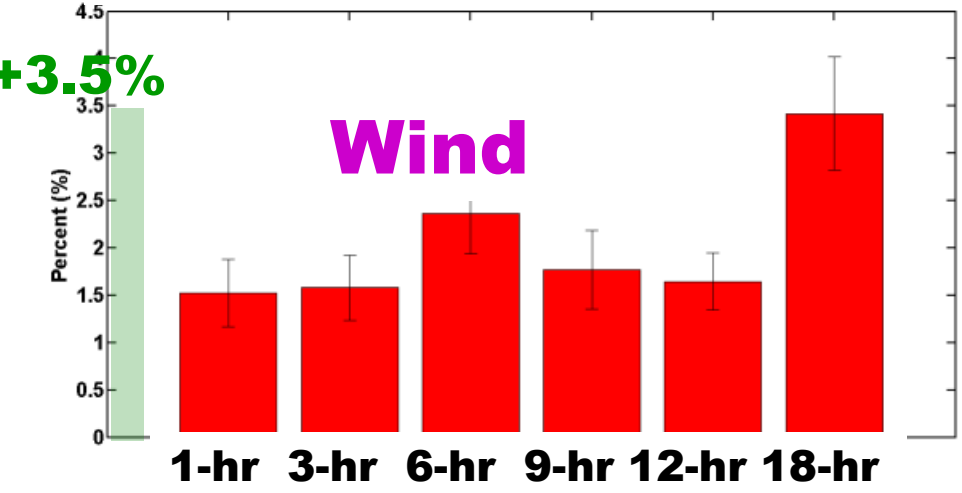
% of obs Retained Without DB/RARS (hourly) (3-hourly)



*Overall % impact from **ALL** radiance data*







Normalized Impact (%)

$$E_N = \frac{(EXPT - CNTL)}{CNTL}$$

Enhanced impact for forecasts farther from GFS partial cycle

100-1000 hPa RMS mean

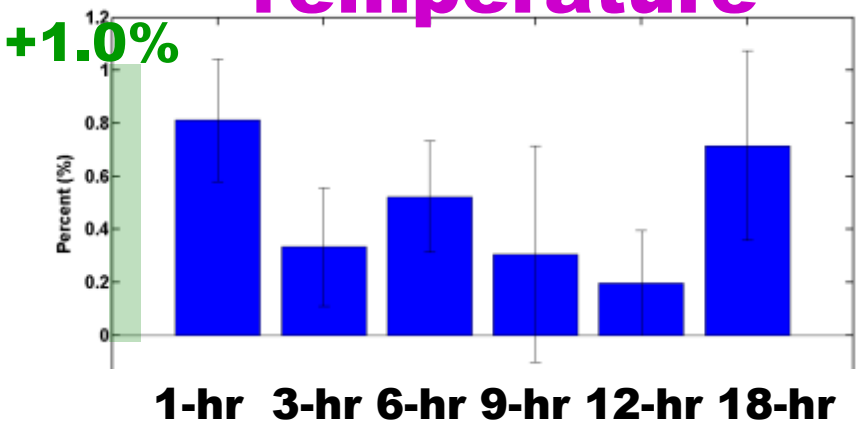
Radiosonde verification

Four-week retro (1-28 Sept. 2017)

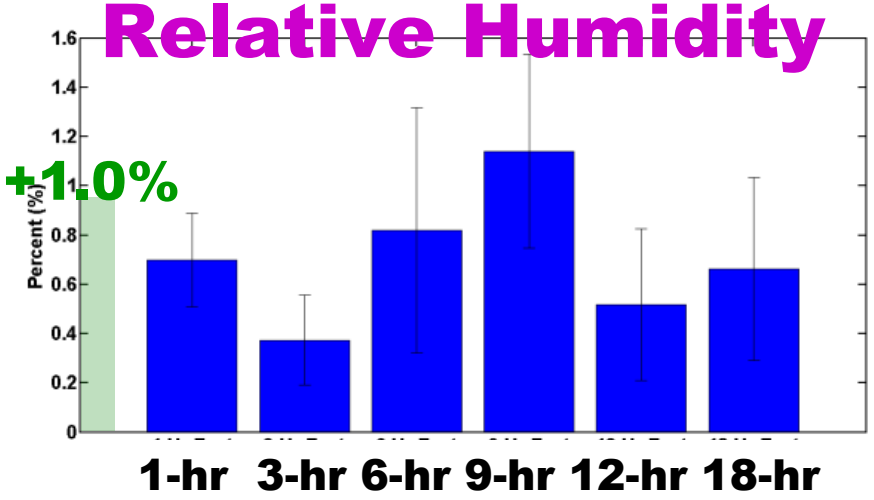
Init Hour	11,23z	9,21z	6,18z	3,15z	0,12z	18,6z
Fcst length	1	3	6	9	12	18
Hrs since GFS	2	0	9	6	3	9

*Overall % impact from **DIRECT BROADCAST** data*

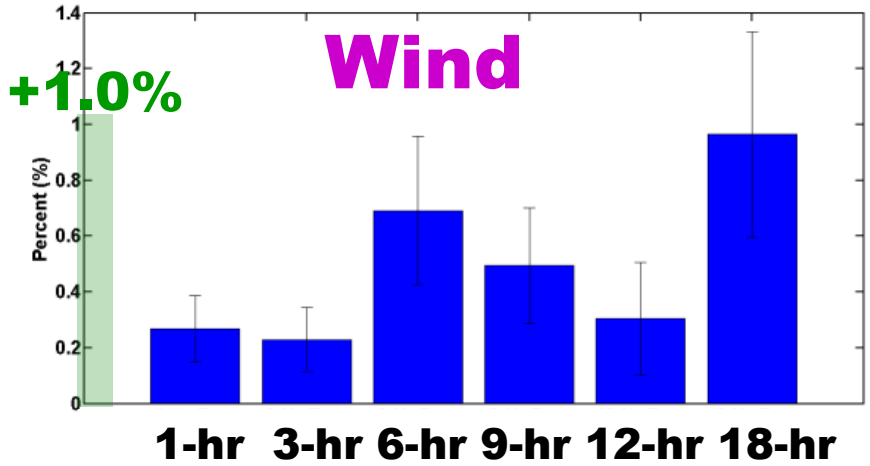
Temperature



Relative Humidity



Wind



100-1000 hPa RMS mean

Radiosonde verification

Four-week retro (1-28 Sept. 2017)

Normalized Impact (%)

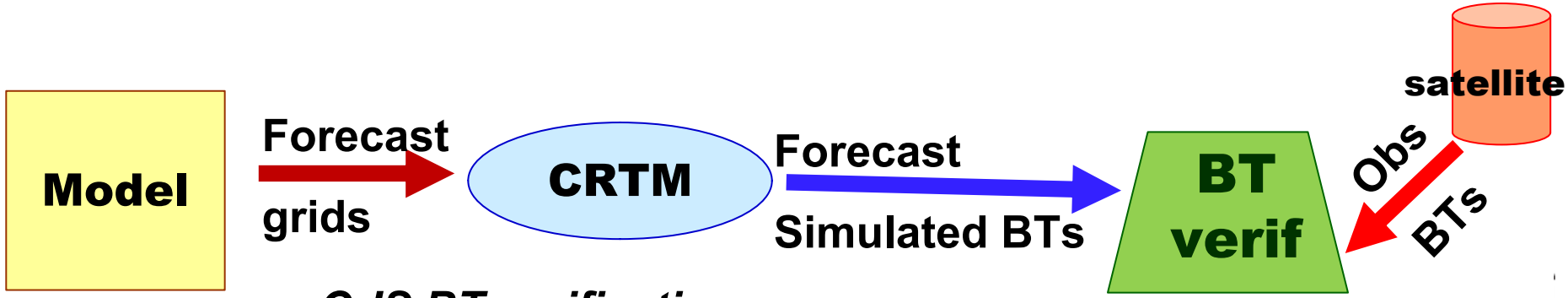
$$E_N = \frac{(EXPT - CNTL)}{CNTL}$$

Enhanced impact for forecasts farther from GFS partial cycle

DIRECT READOUT data accounts for about ONE HALF of all of radiance data impact

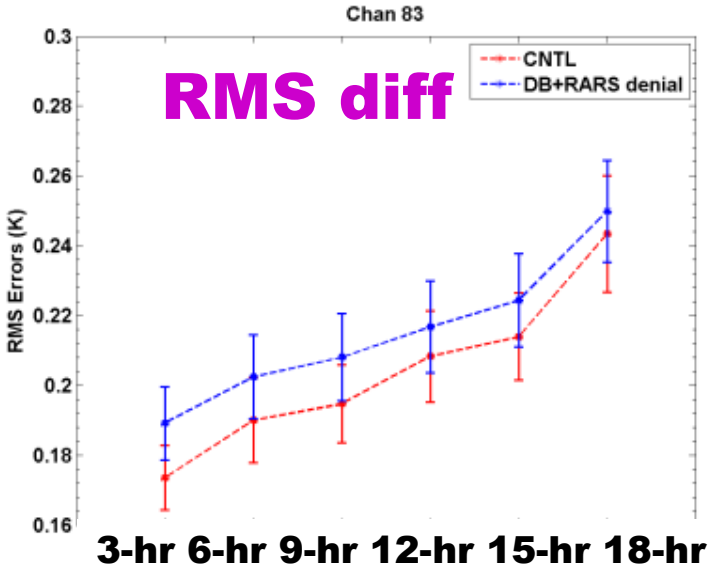
Verification of satellite radiance data impact

- **Verification: rawinsonde or CrIS brightness temperature (BT**
- For CrIS BT, compare RAP forecast files (fed through CRTM with bias correction) to CrIS radiance obs (near space / time)
- Rawinsonde advantages: 3 different independent fields
  Rawinsonde disvads: only valid at 00z, 12z (affects impact), forecast verification only over data rich portion of domain
- CrIS BT advantages: verification for all times over entire domain
  CrIS BT disvads: verification against only one field [Fcn (T,RH)]

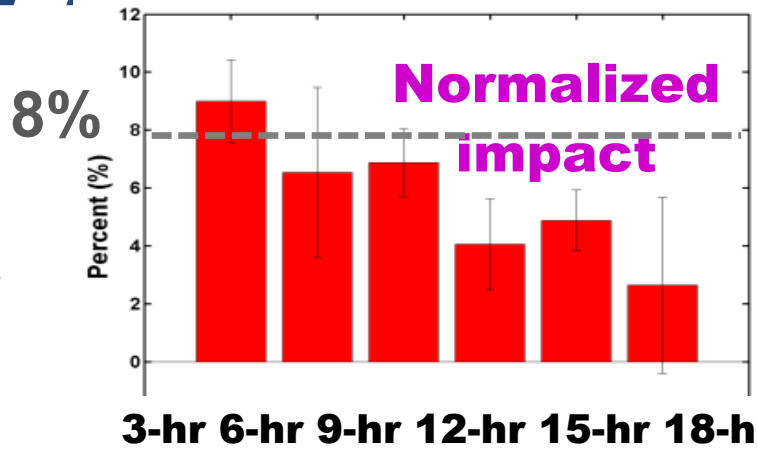


CrIS BT verification process

Overall % impact from DIRECT BROADCAST data

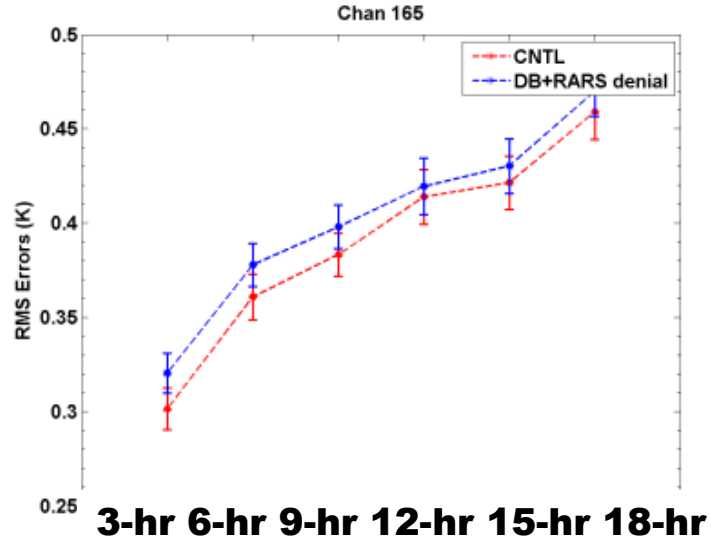


Chan. 83
PWF 218 hPa

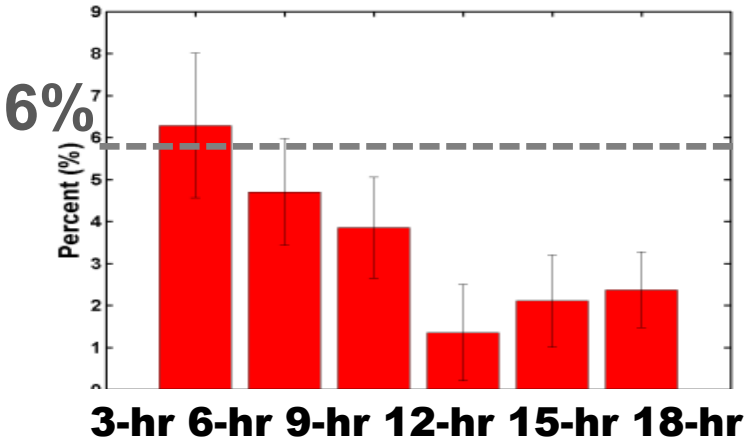


— All data (cntl)

— RARS/DB denial



Chan. 165
PWF 814 hPa



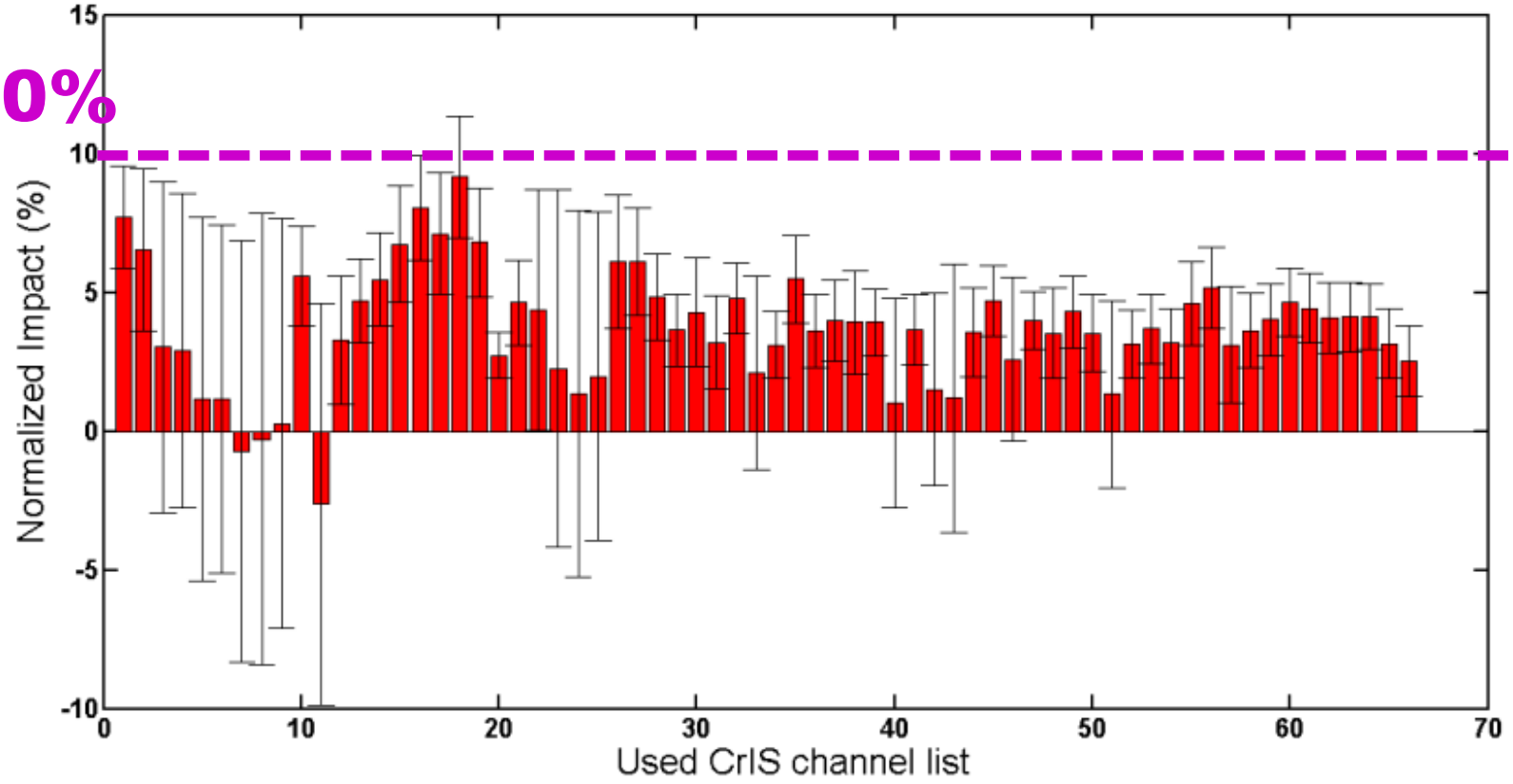
Four-week retro (1-28 Sep. 2017)

CrIS BT verification

Normalized Impact (%)

$$E_N = \frac{(EXPT - CNTL)}{CNTL}$$

*6-h forecast % impact from **DIRECT BROADCAST data***



Four-week retro (1-28 Sept. 2017)

Impact by CrIS channel

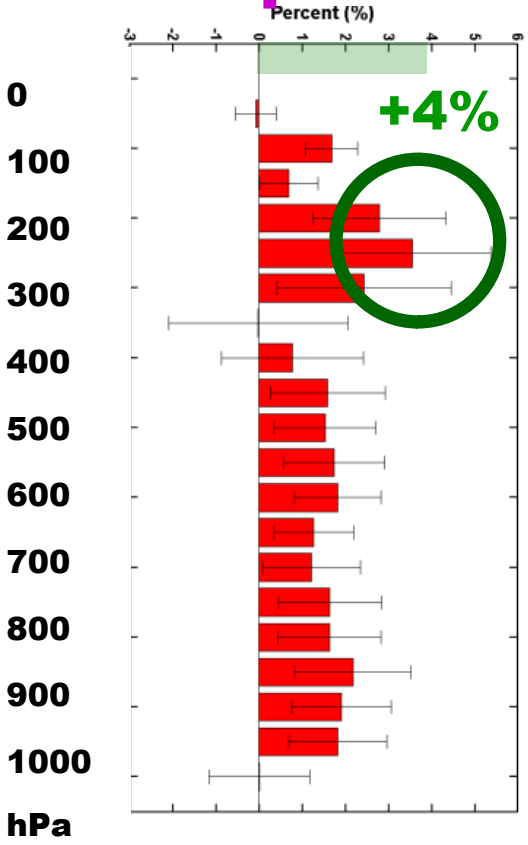
CrIS BT verification

Normalized Errors

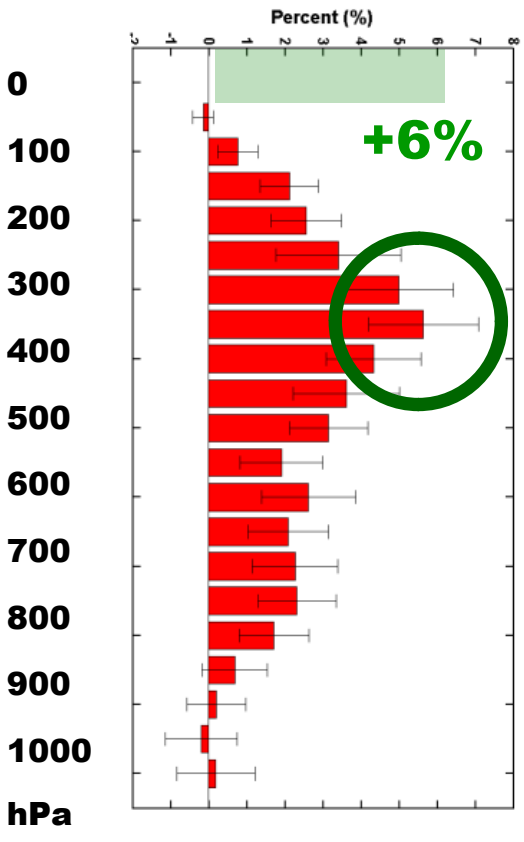
$$E_N = \frac{(EXPT - CNTL)}{CNTL}$$

*6-h forecast % impact from **ALL** radiance data*

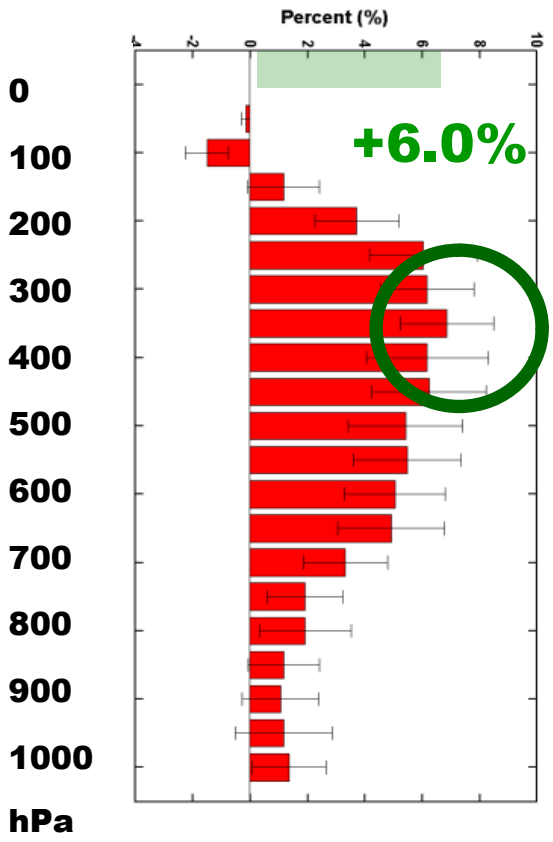
Temperature



Wind



RH



Impact by pressure level

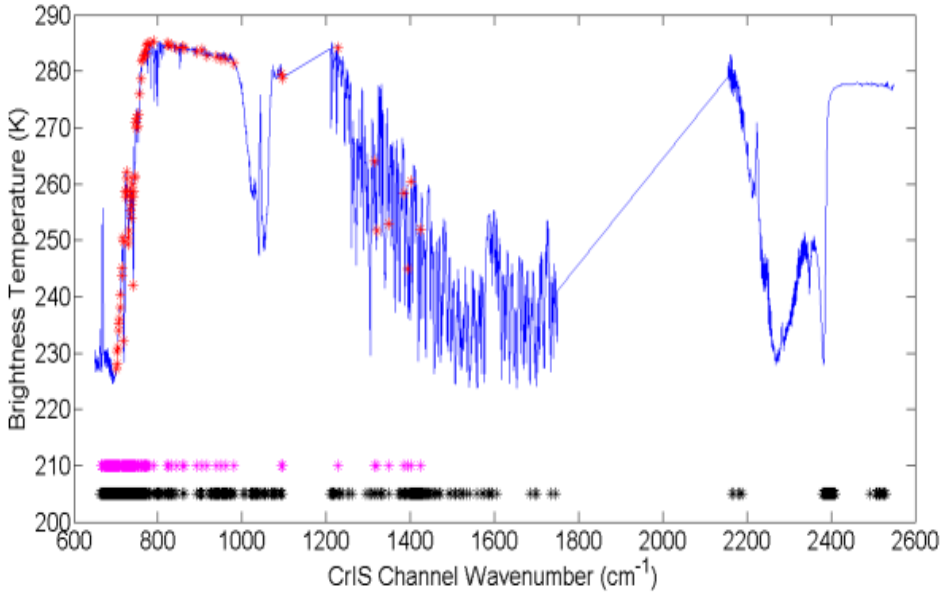
Radiosonde verification

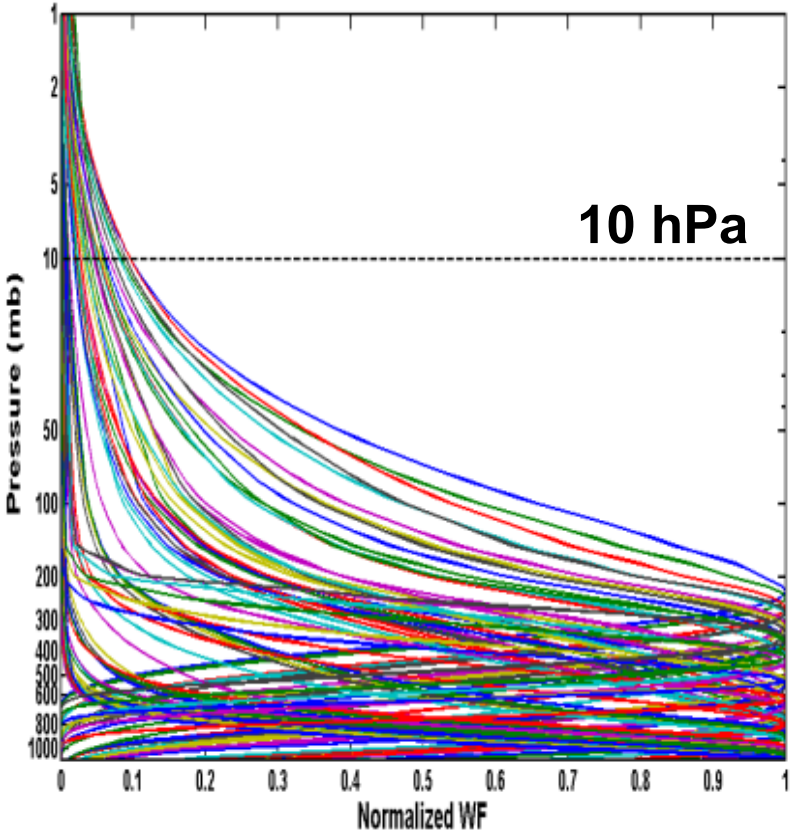
Four-week retro (1-28 Sept. 2017)

Normalized Impact (%)

$$E_N = \frac{(EXPT - CNTL)}{CNTL}$$

Use of CrIS HSIR data within RAP





Simulated BT for CrIS-FSR 2211 channels

CrIS 2211 channels
NESDIS 431-channel set
GDAS 100-channel set
RAP selected 72-channel set
(64 longwave+8 WV)

RAPv4 (2018) CrIS-NSR
(66 channels, SNPP)

RAPv5 (2020) CrIS-FSR
(72 channels, SNPP, N20)

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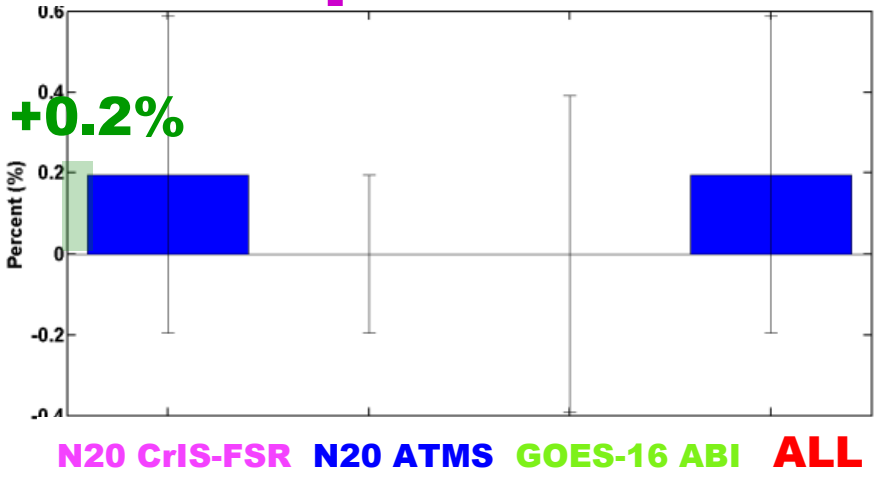
Retrospective radiance data impact test (new data included for RAPv5)

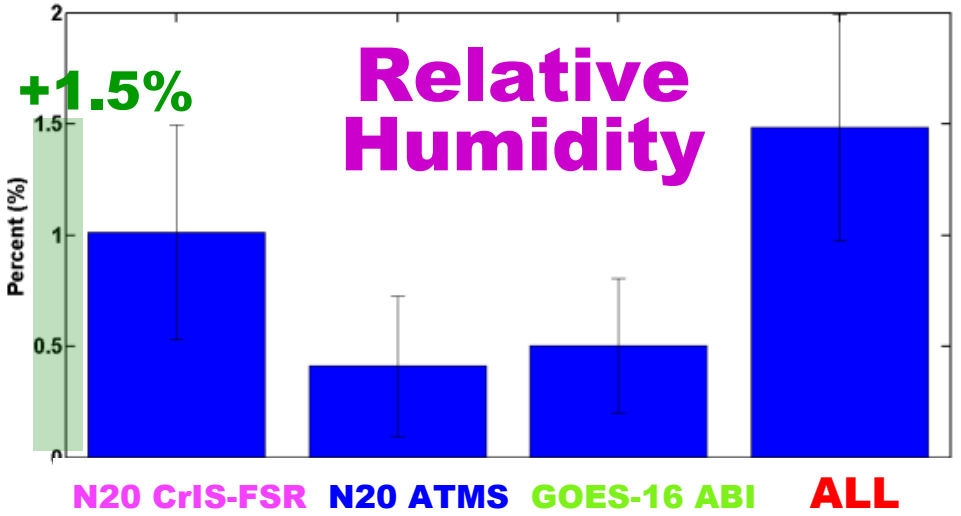
- **Control run (CNTL) – (All data in RAPv4)**
  - 1-h cycling, 7-day retro run (September 09 –15 2018) using RAPv4
  - All data used in operational RAPv4 (conventional + satellite radiance)
- **Experiment runs (NCEP real-time hourly data)**
  - **CNTL + N20 CrIS-FSR (72 channels)**
  - **CNTL + N20 ATMS (18 channels)**
  - **CNTL + GOES-16 ABI (3 channels) (NCEP baseline cloud mask data)**
  - **CNTL + All above new data sets**

6-h forecast % impact from different data sources

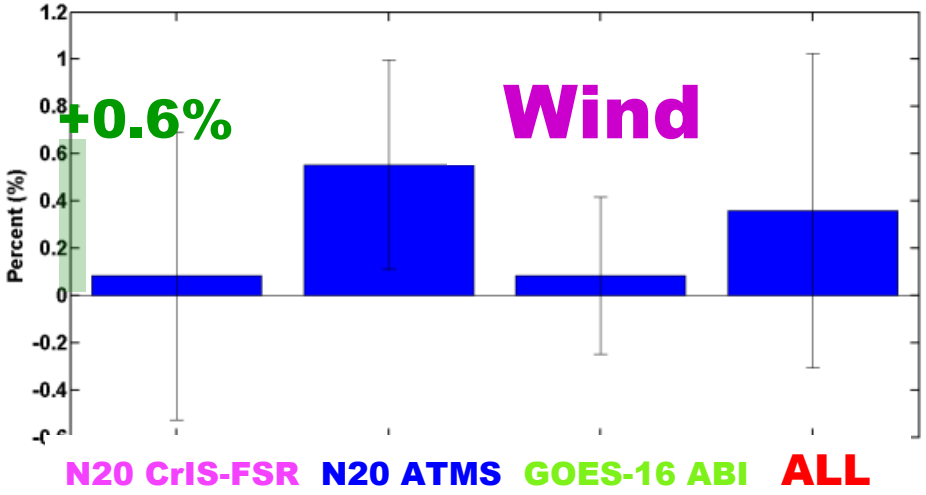
Temperature



Relative Humidity



Wind



Radiosonde verification

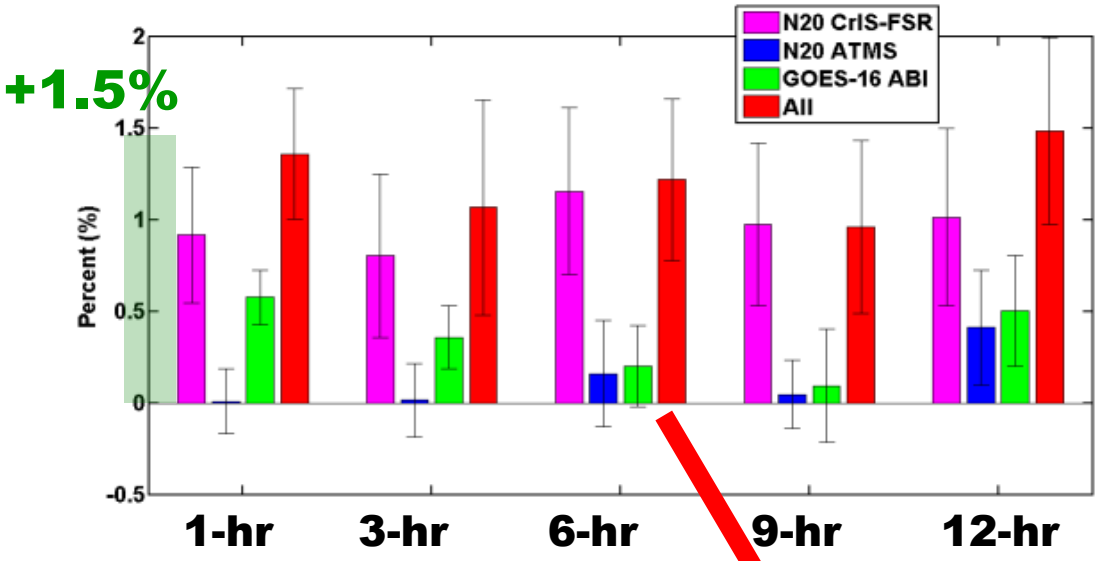
100-1000 hPa RMS mean

One-week retro (9-15 Sept. 2018)

Normalized Errors

$$E_N = \frac{(CNTL - EXPT)}{CNTL}$$

1-12-h forecast % impact from different data sources

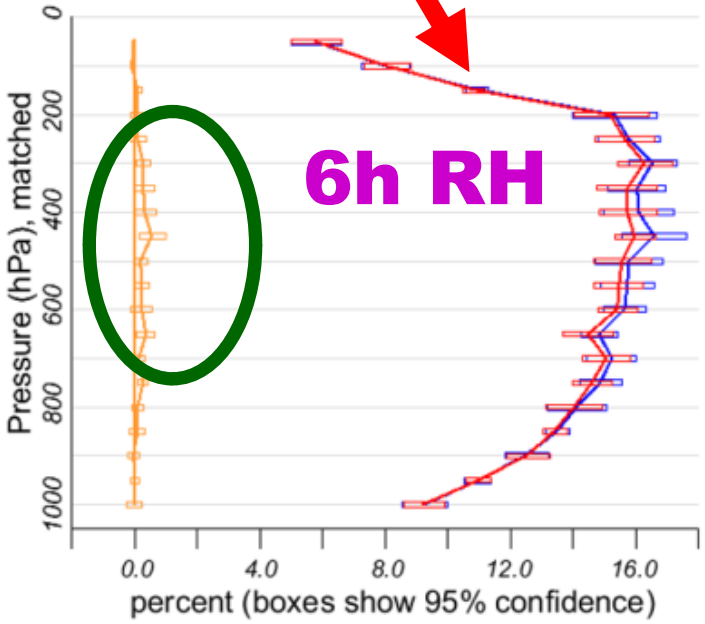


N20 CrIS-FSR
N20 ATMS
GOES-16 ABI
All

100-1000 hPa RMS mean

Radiosonde verification

One-week retro
(9-15 Sept. 2018)



Relative Humidity

All

CNTL (RAPv4)

Summary of results

- For hourly updating models like the RAP, direct broadcast data feeds substantially increase the number of assimilated observations, leading to significant forecast error reductions

- Verification of model forecasts against CrIS brightness temperatures, rather the radiosonde observations, reveals even larger data impacts from assimilation of satellite data and direct broadcast data

- Adding CrIS-FSR data from N20 (72 channels) leads to further RAP forecast error reductions, especially for relative humidity

To be considered by CGMS:

- Underscore the importance of low latency data for LEO satellites and implement as a firm requirement.