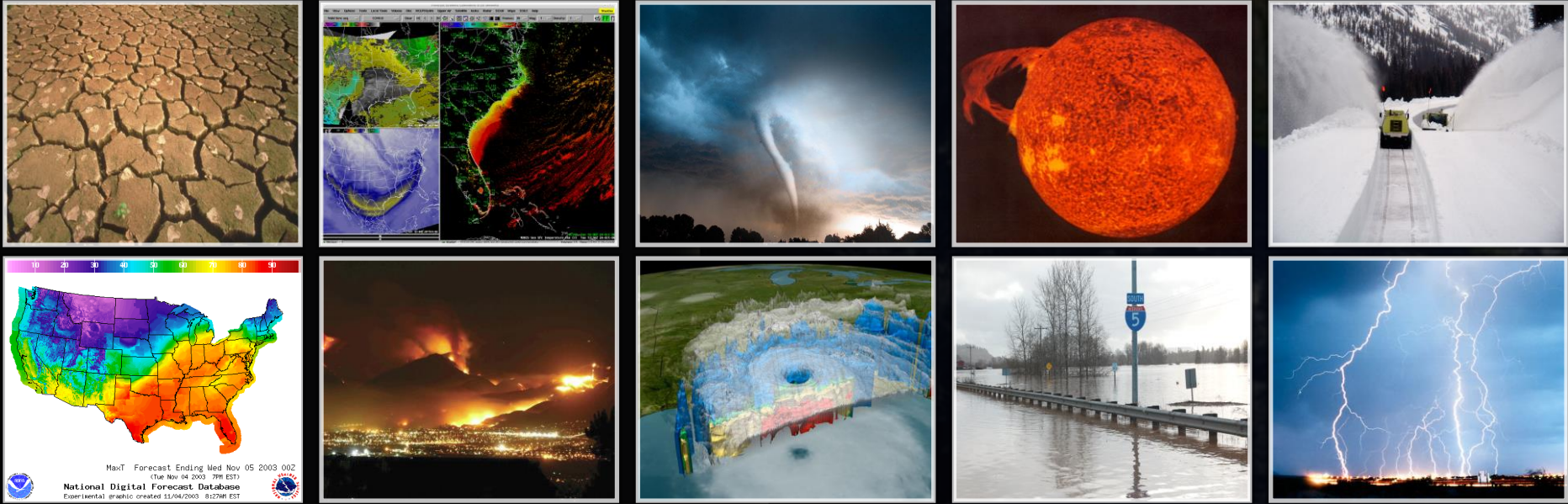


# Using Satellite Sounder Observations at NCEP and Future Plans

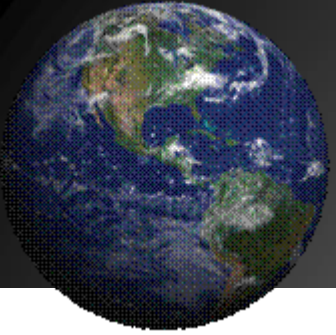


**James G. (Jim) Yoe**

NOAA/NWS National Centers for Environmental Prediction

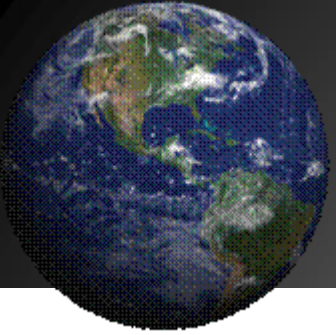
Community Meeting on NOAA Satellites

Sep 29- Oct 1, 2020



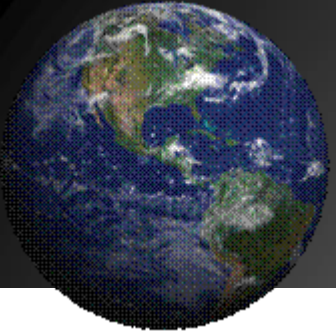
# Overview

- Acknowledgements
- Background - NCEP Production Suite (NPS)
- Current Use of Sounder Observations
- Future Use of Sounder Observations
  - Plans, Opportunities, Challenges
- Conclusions
- ***Opening Thought – Intent is to inspire discussion, not dazzle with flash***



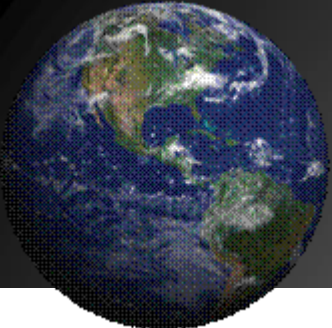
# Acknowledgements

- Recognize those from whom slides and ideas are borrowed
  - Vijay Tallapragada – NCEP/EMC
  - Steve Weygandt – OAR/ESRL
  - Andrew Collard - IMSG with NCEP/EMC
  - Louis Uccellini – NWS
  - David Groff – (formerly) IMSG with NCEP/EMC

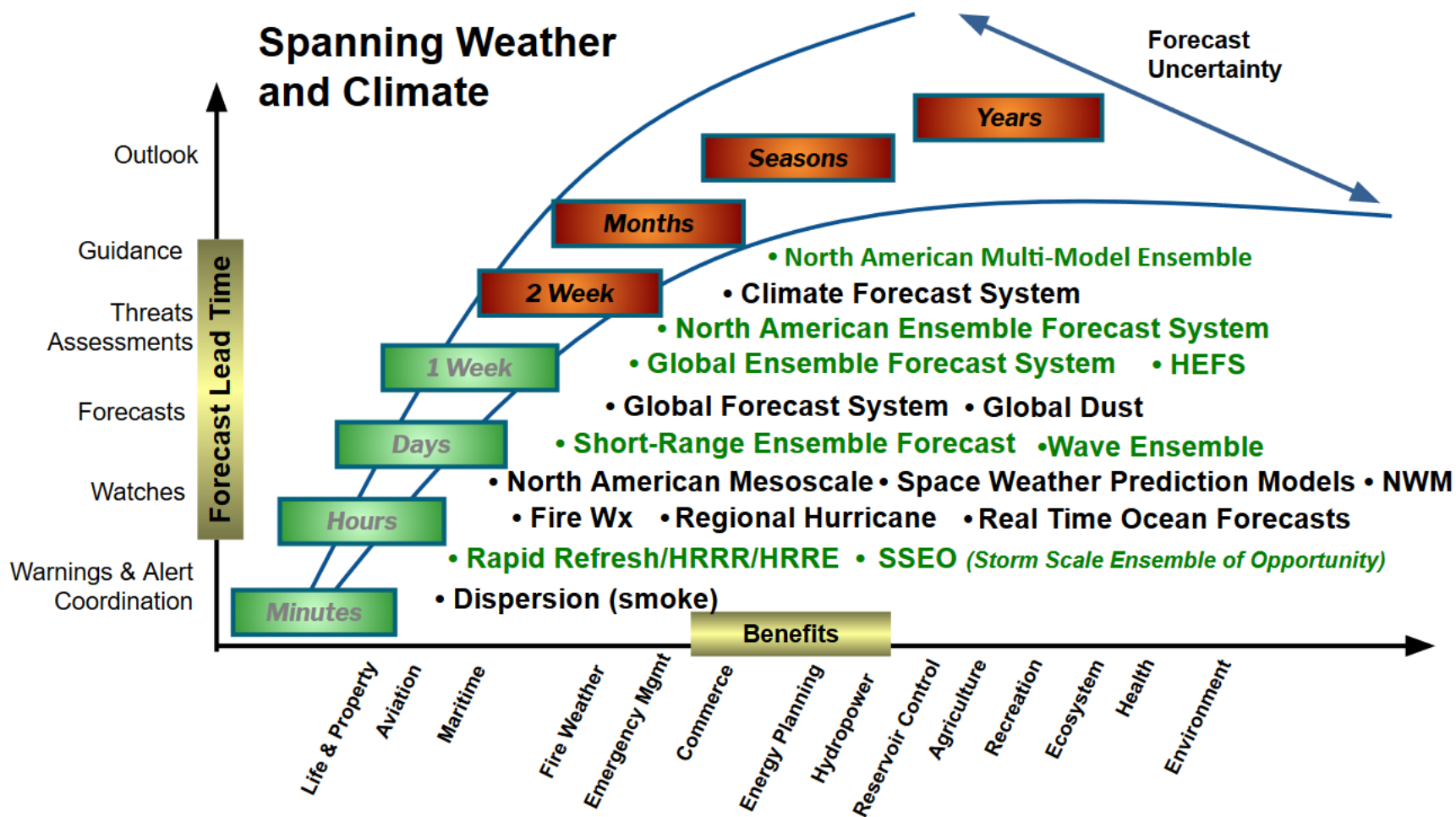


# Background

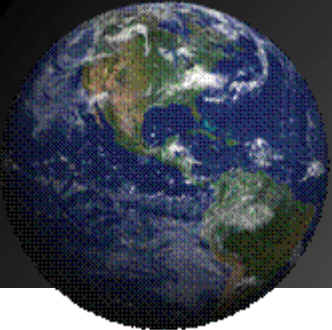
- The NCEP Production Suite (NPS)
- NCEP Model Skill
- Evolution of the NPS
  - Unified Forecast System (UFS)



# NCEP Production Suite (NPS): Seamless Suite of Model Forecasts From Mesoscale to S2S Increasingly Based on Multi-Model Ensembles



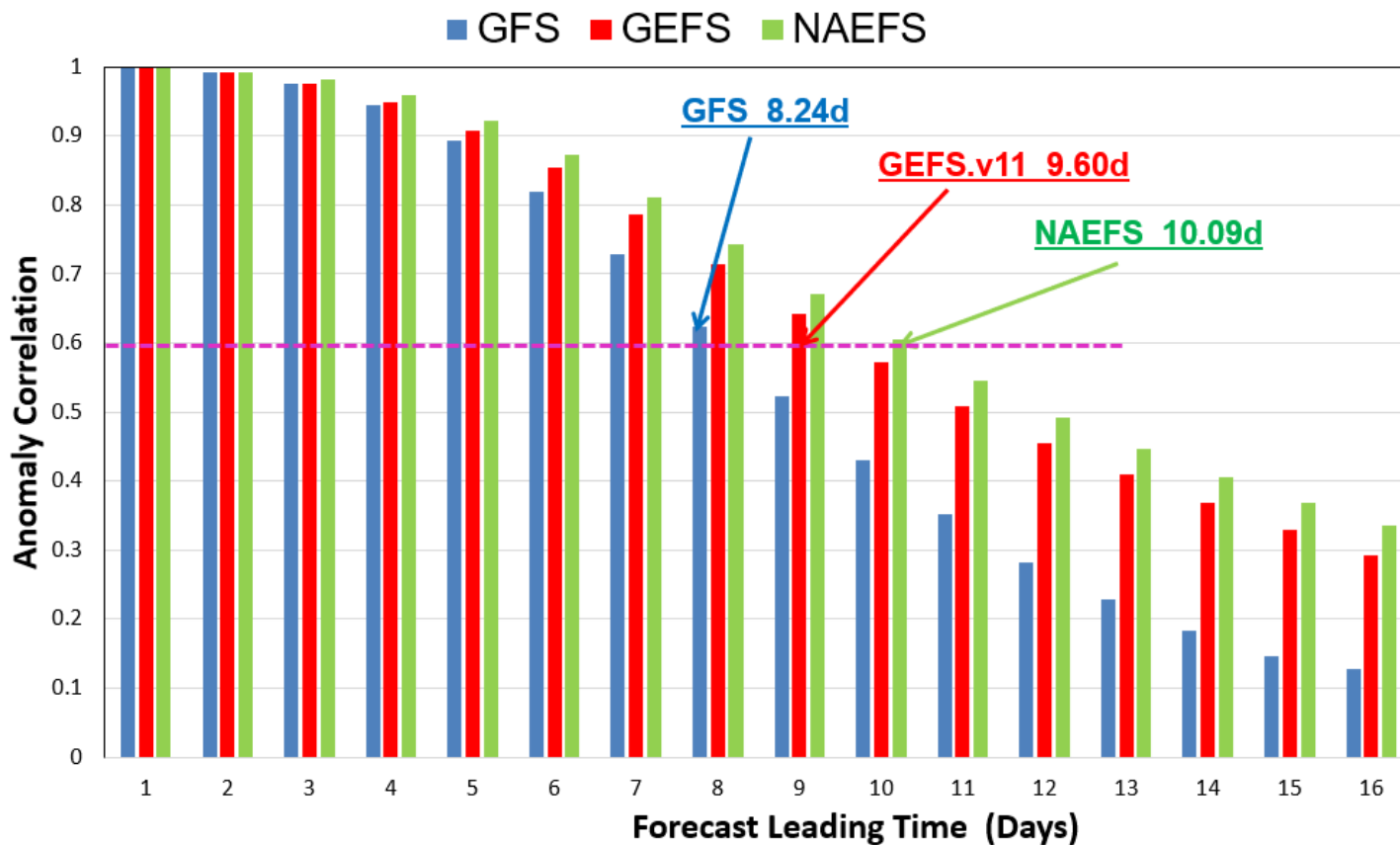


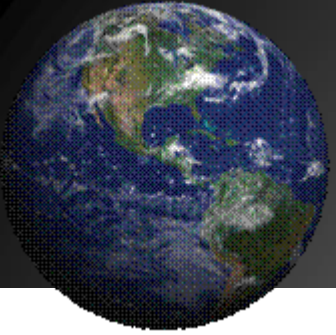


# NWP Skill: Recent Scores for GFS, GEFS, & NAEFS

## NH Anomaly Correlation for 500hPa Height

Period: February 1<sup>st</sup> 2019 - January 31<sup>st</sup> 2020

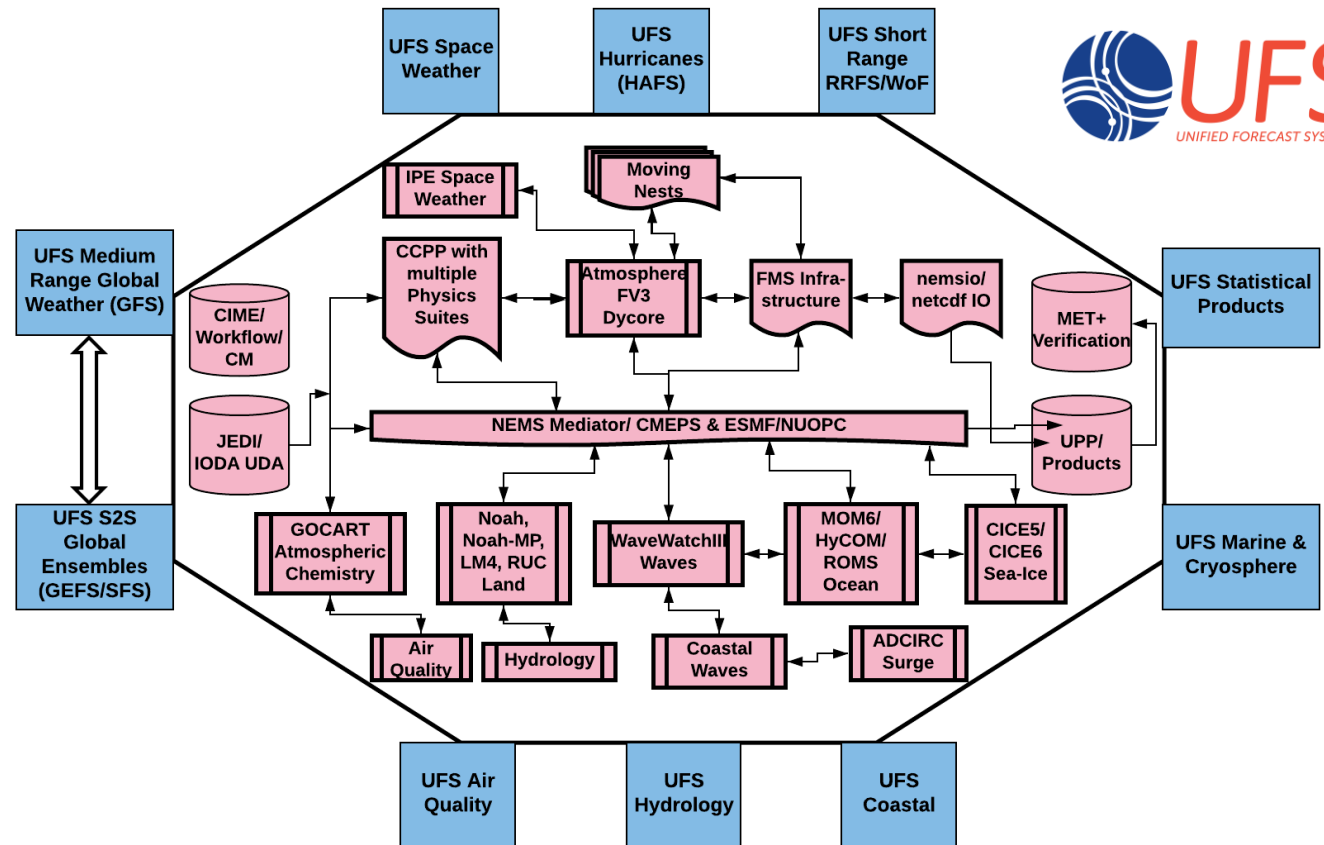


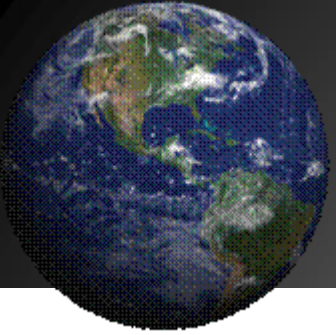


# NPS Transitioning to UFS Applications

Conceptual UFS applications in production covering all NPS applications.

Components of UFS are configured to develop distinct applications while maintaining the dependencies between the applications and products

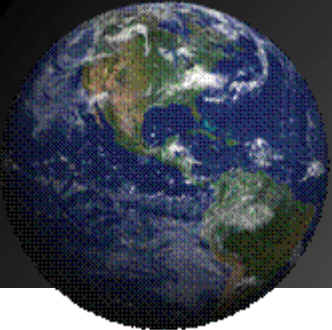




# Current Use of Sounder Observations

- Impact of Observations in the Global NWP
- History of Transitioning Sounder Observations to Operations
- Updating Models and Data Latency

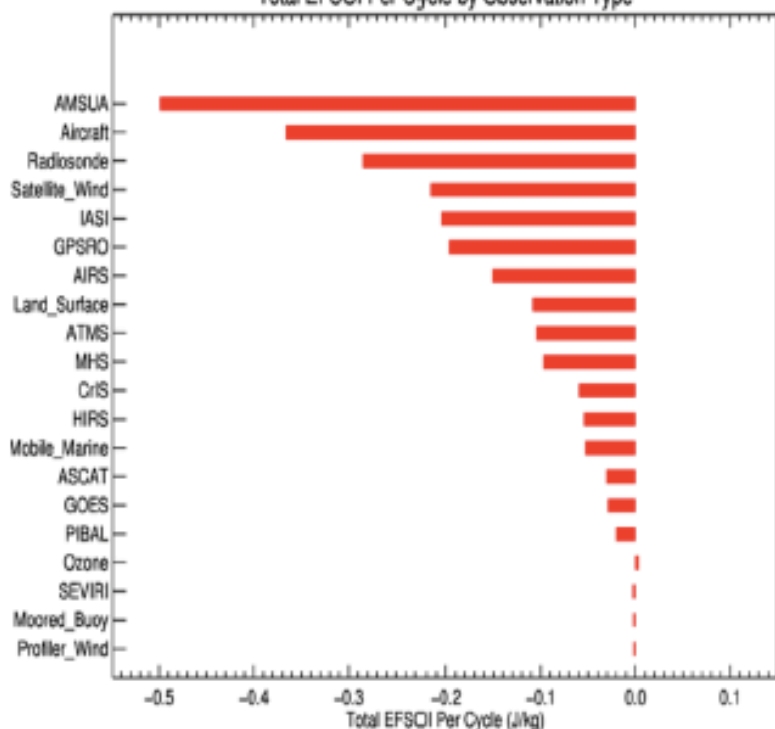




# Impact of Data Used in the NCEP Global Model

Ensemble Forecast Sensitivity to Observation Impact (EFSOI)

Total EFSOI Per Cycle by Observation Type



Total EFSOI impacts per cycle based on EnSRF products from a low resolution 4DVar configuration of the 2016 GSM GFS. (Courtesy of David Groff)

## Microwave:

**AMSU-A:** NOAA-15, 18, 19, MetOp-A/B/C, Aqua

**ATMS:** S-NPP, NOAA-20

**MHS:** NOAA-18, 19, MetOp-A/B/C

**SSMIS:** DMSP-F17

**Saphir:** Megha-Tropiques

## Infrared:

**AIRS:** Aqua

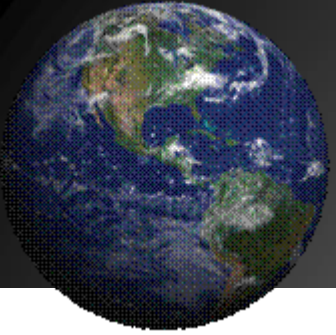
**IASI:** MetOp-A/B

**CrIS:** S-NPP, NOAA-20

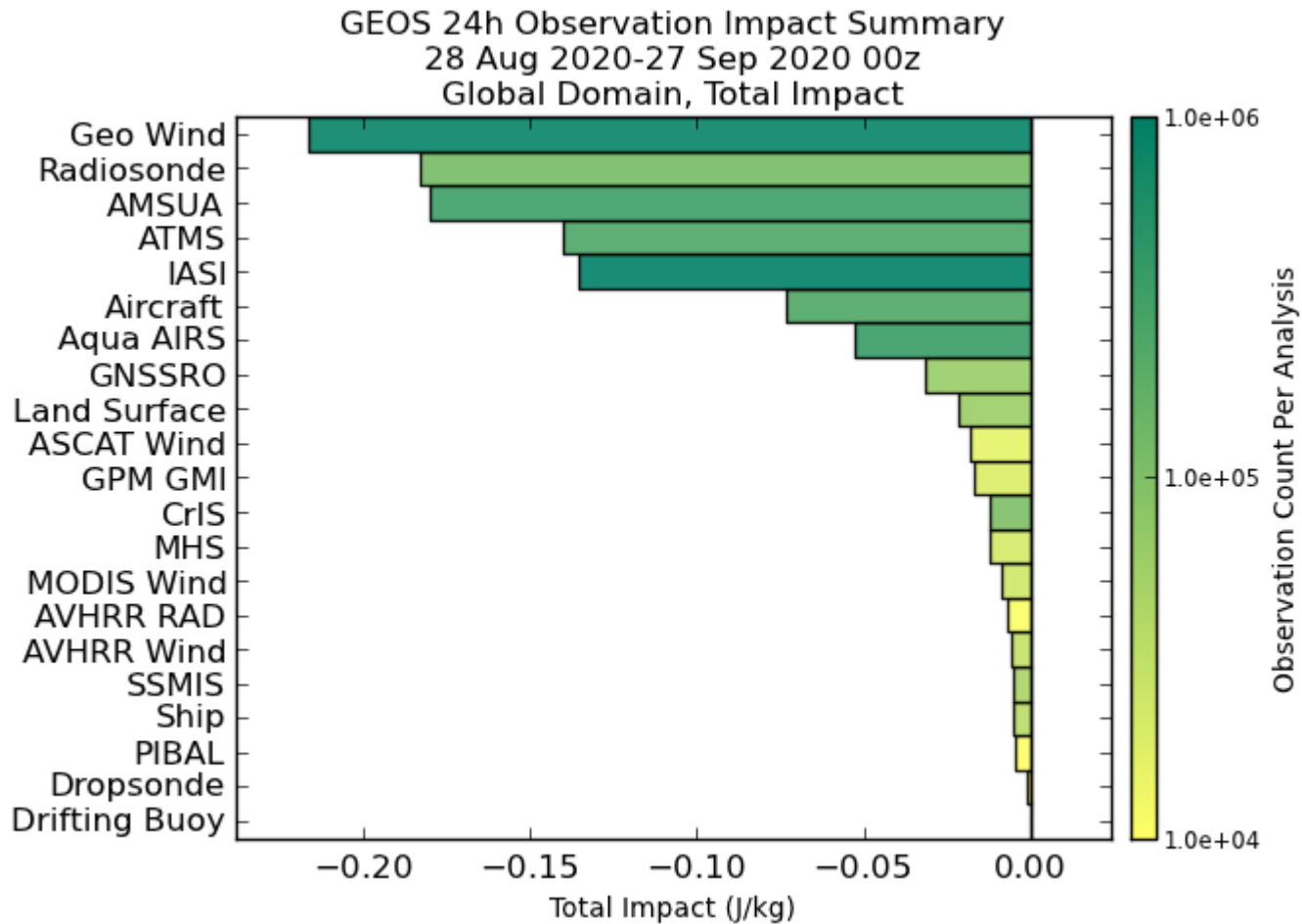
**SEVIRI:** Meteosat-11 (Meteosat-8, Himawari-9 and GOES-16/17 infrared imagers coming soon!)

**AVHRR:** MetOp-A, NOAA-18

RED=All Sky Over Sea



# Impact of Data Used in the NASA GEOS-5 Model



[https://gmao.gsfc.nasa.gov/forecasts/systems/fp/obs\\_impact/](https://gmao.gsfc.nasa.gov/forecasts/systems/fp/obs_impact/)

# Time Elapsed Between Sounder Launch and Operational Assimilation (GFS)

		Launch Date	Assimilation Date	Time Elapsed
Microwave Sounders	AMSU (POES)	Multiple	Multiple	2 Years +
	SNPP ATMS	28 Oct 2011	22 May 2012	207d
	NOAA 20 ATMS	18 Nov 2017	30 May 2018	193d
Hyperspectral IR Sounders	Aqua AIRS	04 May 2002	31 May 2005	2 Years +
	Metop 1 IASI	19 Oct 2006	24 Feb 2009	2 Years +
	SNPP CrIS	28 Oct 2011	20 Aug 2012	297d
	NOAA 20 CrIS	18 Nov 2017	30 May 2018	193d
GNSS Radio Occultation	COSMIC	15 April 2006	01 May 2007	382 days
	KOMPSAT-5	08 Aug 2013	10 Oct 2019	6 Years +
	COSMIC-2A	25 Jun 2019	~May 2020	~10 months
GOES-R Series AMVs	GOES-16 (East)	19 Nov 2016	05 Jan 2018	412 days
	GOES-17 (West)	01 Mar 2018	10 Oct 2019	588 days



# Satellite radiance assimilation for rapidly updating regional models



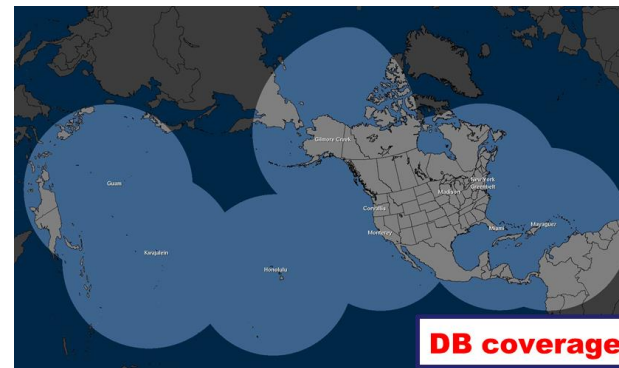
## Hourly RAP / HRRR radiance assimilation

- AMSU-A (RARS)
  - MHS (RARS)
  - IASI (DB, RARS)
  - ATMS (DB, RARS)
  - CrIS (FSR\*) (DB, RARS)
  - GOES-16 ABI Radiance data\*
  - AIRS, SSMIS, GOES-15 sounder
- HRRR-AK radiance DA\*

\* = in RAPv5, HRRRv4

**DB = Direct Broadcast**

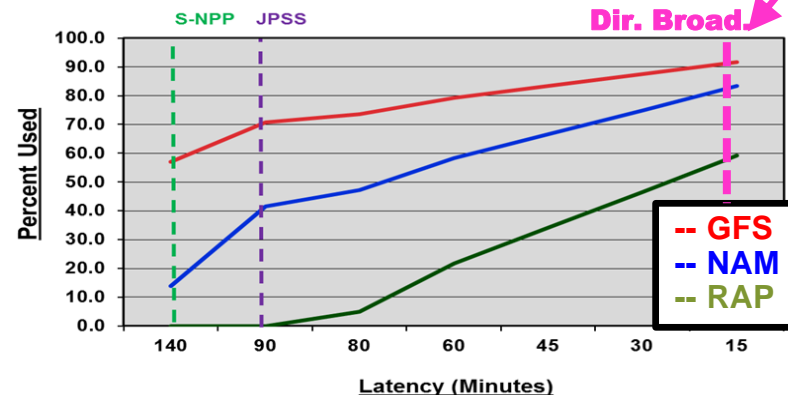
**RARS = Regional ATOVs Retransmission Service**



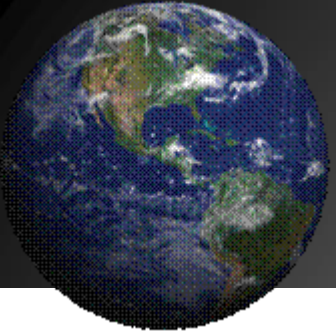
**25 min.  
Observation  
data cutoff  
for RAP/HRRR**

**Direct  
Broadcast  
data critical for  
hourly  
cycling**

**Data Latency and Percent of Data Used in Operational NWP**

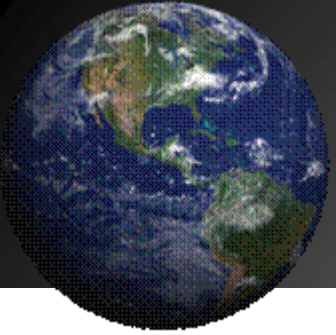


**Steve Weygandt, NOAA/ESRL – Haidao Lin,  
NOAA/ESRL, CIRA**



# Future Use of Sounder Observations

- Next Generation Satellite Systems present opportunities ...
  - Metop SG
  - MSTG – Hyperspectral IR Sounder in Geo orbit
    - And other n
  - NOAA's Next Generation GEO-XO platforms
  - SmallSats/CubeSats
  - Commercially procured sounder observations
  - Improved Science and Methodology
    - All-sky radiance assimilation (over all surfaces)
    - Coupled Data Assimilation
    - Open Model and DA Development (via UFS and JEDI)

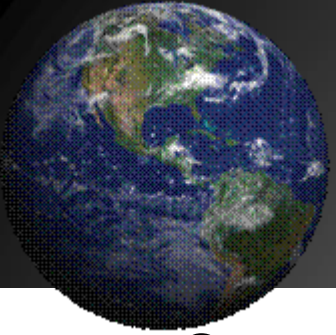


# Future Use of Sounder Observations

- ... and Challenges

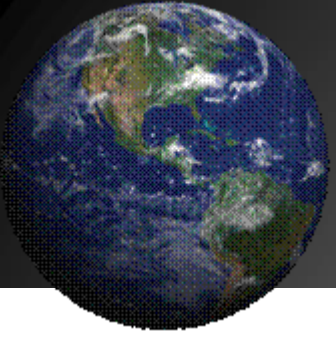
- Large Data Volumes – created by high spectral and temporal resolution
- Latency requirement (more exacting)
- Channel selection(s)
- Ensuring that Implementation keeps pace with development
- Loss of Continuity
  - Threat to microwave sounder frequencies through RFI
  - Retention of the 15 $\mu$ m band for infrared sounders
  - Co-located imagers not available on SmallSats
  - Lifetime of SmallSats and Commercial Sounders
    - Cal/Val and Implementation need to be expedited





# Summary

- Sounder Observations are and will remain a data cornerstone for the NPS
  - New technologies, platforms will be developed and acquired to meet observational needs to support NWP as identified via user engagement efforts (refer to talks of September 29); still....
- Optimal benefit from Future Sounder Observations for NOAA's NWP depends not only on the sounders themselves but on ensuring capabilities are in place to
  - Move, process, & access large data volumes quickly
  - Accelerate implementation of new sounders from varied sources
  - Develop DA to exploit full capability of new sounders



# Questions?

- ?



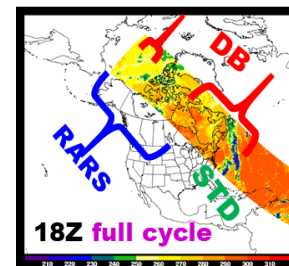
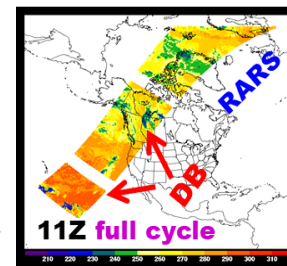
# Satellite radiance assimilation for rapidly updating regional and global models



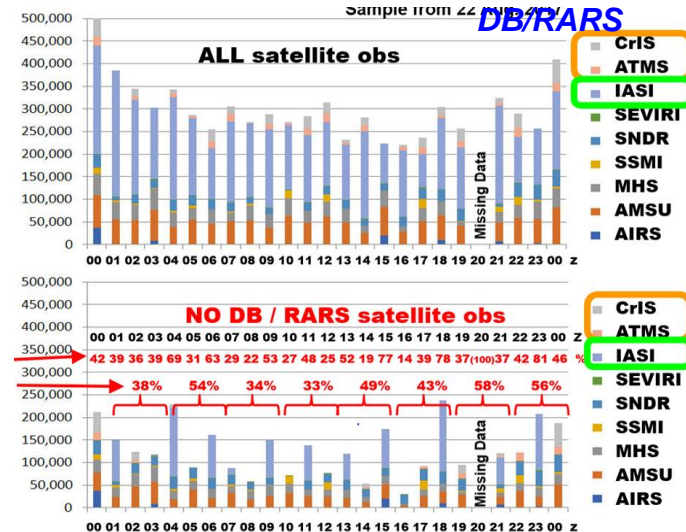
## Challenges and questions

- Will the data be **operationally available** at **low enough latency** for rapidly updating? **(direct broadcast critical for hourly updating)**
- Can we improve on the **bias correction** for regional models?
- What degree of **channel selection** is needed for regional models compared to global models (because of the lower model top)?

Sample data swaths from  
*Standard, RARS,  
Direct Broadcast*



Sample radiance obs counts w/ and w/o DB/RARS



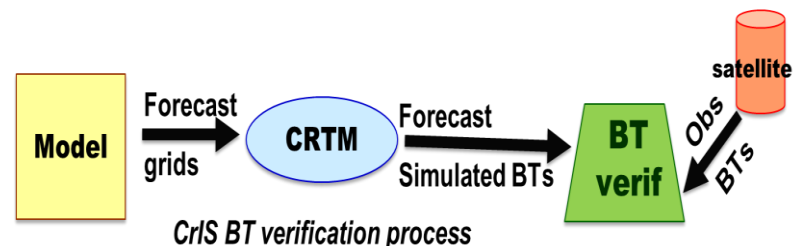


# Satellite radiance assimilation for rapidly updating regional and global models

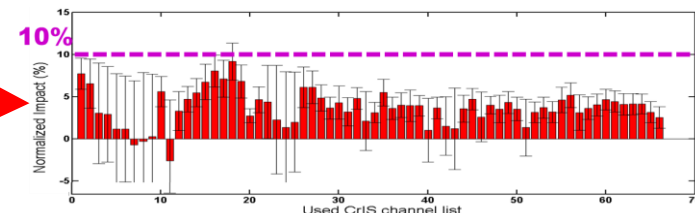


## Challenges and questions

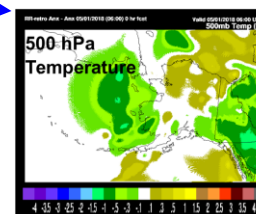
- Quantifying regional radiance assimilation impact for data rich and data poor regions? **(use of satellite radiance-based verification approaches?)**
- Application for storm-scale models **(inclusion in 3-km HRRR-AK for 2020, and RRFS - Rapid Refresh Forecast System - in 2023)**
- Timing for introduction of enhancements (all-sky radiance, evolution to JEDI)



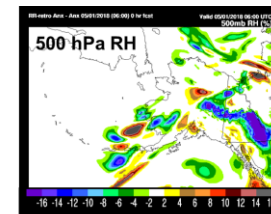
**Percent impact in 6-h RAP forecasts from denying DB and RARS on CrIS BT verification**



**Radiance data impact in 3-km HRRR/AK**



Sample analysis difference (A-A) from inclusion of radiance data





# Satellite radiance assimilation for rapidly updating regional and global models



## Science / Technical Issues

- All sky radiances
- Transition to JEDI
- Quality control issues
- CRTM enhancements
- Correlated observation errors
- Regional bias correction issues

## **Evolving / future needs for satellite radiance DA**

## Monitoring / Assessment

- Further streamlining of sensor/channel monitoring
- Increased FSOI evaluation
- Further application of novel radiance data verification techniques

## Coordination / Communication

- Further streamlining of data processing and formatting for operational DA
- Coordination of code development for current and new sensors within JEDI

## Global Rapid Refresh Models

- Work toward global hourly updating
- Data availability / latency issues
- Better integration of radiance and product assimilation