Analysis of an Observing System Experiment for the Joint Polar Satellite System

S. Lord, George Gayno[1] and Fanglin Yang[1]

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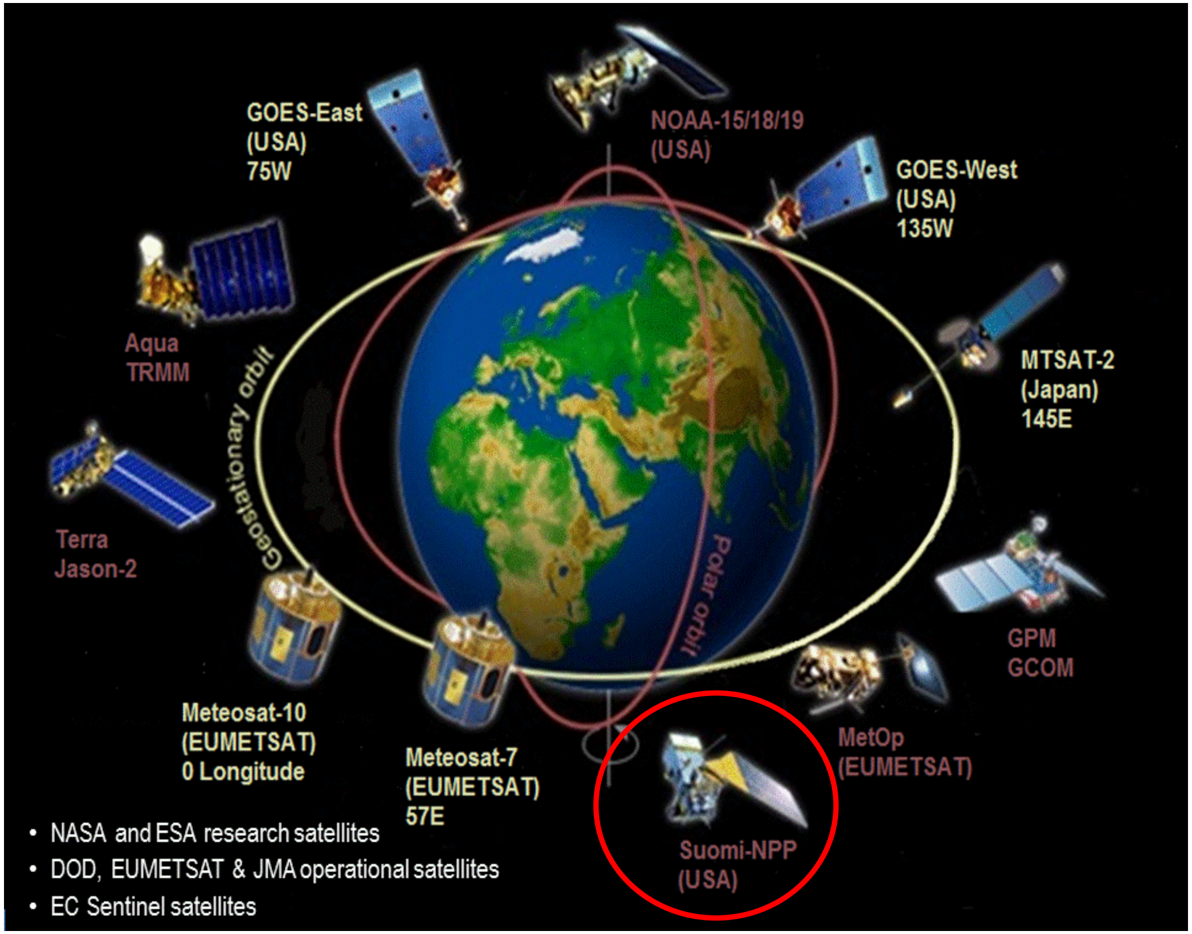
[1] I. M. Systems Group at NCEP/EMC

Outline

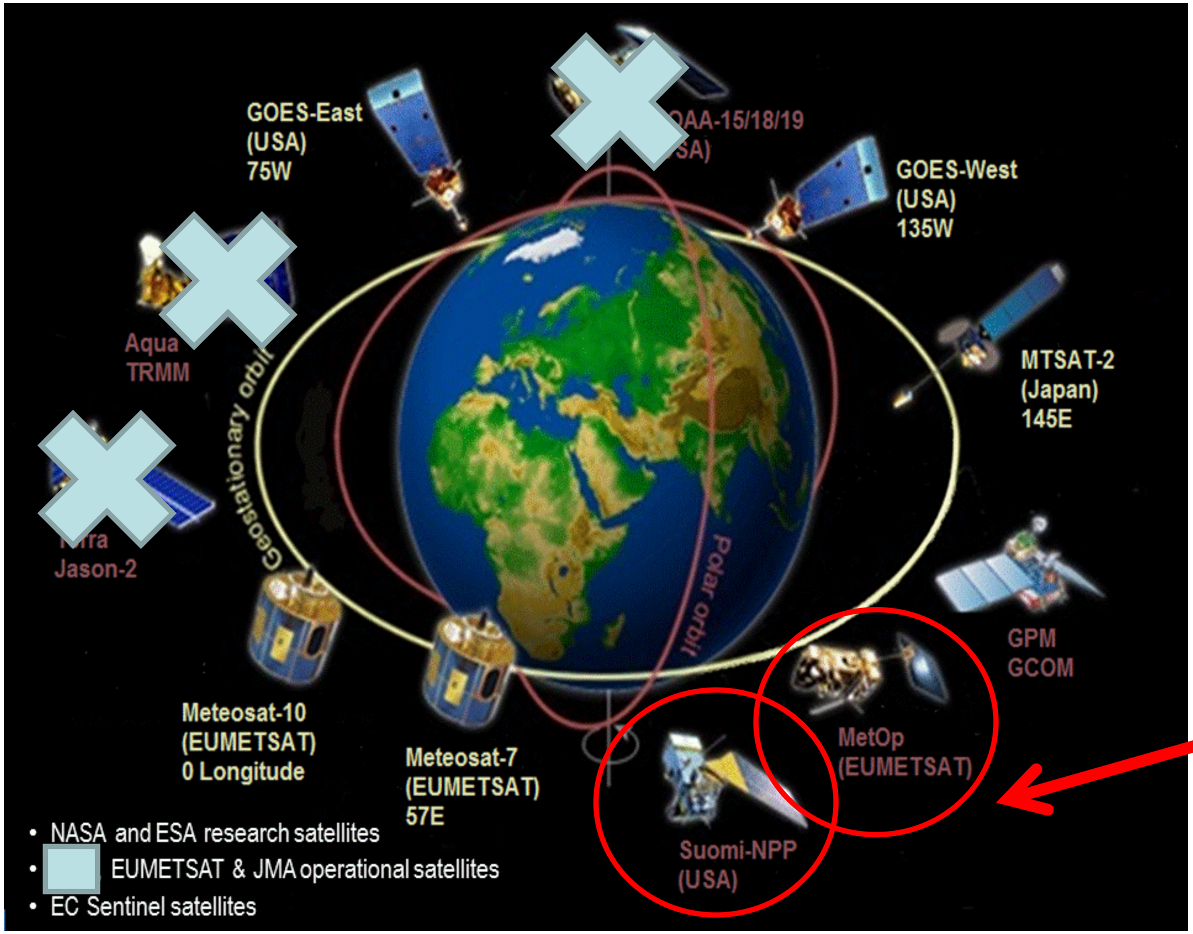
- The Joint Polar Satellite System (JPSS)
- Observing System Experiments (OSEs)
- Evaluating Forecasts (examples)
- Evaluating JPSS OSE
  - "Classical"
  - "Value added"
- Summary

Current Satellite System



- Other systems are Geostationary (white), GNSSRO (radio occultation, not shown)

Future Joint Polar Satellite System (JPSS)



- Future polar-orbiting system (red) will be
  - 2 Orbit-
  - 4 Sounder (2O4S)

- Other systems are Geostationary (white), GNSSRO (radio occultation, not shown)

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Observing System Experiments (OSEs)

- Purpose: to measure impact of designated observing systems within a Numerical Forecast System (NFS)

- Why: Adds accountability and can be used to guide strategic decisions for spending on (expensive) observations

- How: Execute NFS with full complement of observing systems (control) and without one or more systems (expts)
  - E. g. radiosondes, polar-satellites, GNSSRO

Observing System Experiments (OSEs) (cont)

- What: Numerical Forecast System (NFS) contains
  - Observing Systems (OS)
  - Data assimilation (DA) system
  - Forecast model (Global Forecast System model, GFS)
  - Verification (standard scores)

- Remarks:
  - Results depend on both observations and NFS model and DA
  - Statistical significance can be hard to achieve
    - GFS is very accurate so small changes to OS may not produce large impacts
    - Results can be noisy, and seasonally, hemispherically and case dependent
  - OSEs are expensive due to DA and periodic forecasts and require expensive High Performance Computer resources
  - Other techniques are potentially useful (e.g., Forecast Sensitivity to Observations, FSO)

JPSS OSE

- Operational GFS (2013)
  - T574/L64 (27 km) model
  - 3-D hybrid DA
  - Daily assimilation cycle (6 hourly)

- Assimilation began 15 July 2012 – 15 Feb 2013 (7 months)
  - Model runs 00, 06, 12, 18 UTC until 3 November 2012, 00 UTC only thereafter
  - Evaluated 00 and 12 UTC runs beginning on 1 August 2012
  - Covers 3 seasons
  - 293 cases (199 at 00 UTC, 94 at 12 UTC)

- Experiments
  - Control (all JPSS-relevant observations)
  - NOPM (remove NOAA polar-orbiting data in PM orbit)
  - Operations is bonus extra

JPSS OSE (Cont)

- Observations
  - Conventional (radiosondes, surface, aircraft, marine)
  - Geostationary (GOES, Meteosat)
  - GNSSRO (COSMIC, etc)

OSE

Polar Observing System	Orbit	Control (CNTL)	No PM Orbit (NOPM)
AMVs (Aqua)	PM	Yes	No
AMVs (Terra)	AM	No	No
MetOp-A ASCAT	Mid-AM	Yes	Yes
MetOp-A IASI	Mid-AM	Yes	Yes
MetOp-A AMSU-A	Mid-AM	Yes	Yes
MetOp-A MHS	Mid-AM	Yes	Yes
Aqua AIRS	PM	Yes	No
NOAA-19 AMSU-A	PM	Yes	No
NOAA-19 MHS	PM	Yes	No

OPS additions

Polar Observing System	Orbit
Aqua (AMSU-A)	PM
NOAA-18 (AMSU-A, MHS)	PM
NOAA-15 (AMSU-A)	PM→AM
NOAA-17 (HIRS)	PM
NOAA-19 (HIRS)	PM

- Other related work
  - McNally (2012)
  - Cucurull and Anthes (2015)
  - Boukabara et al (2015)

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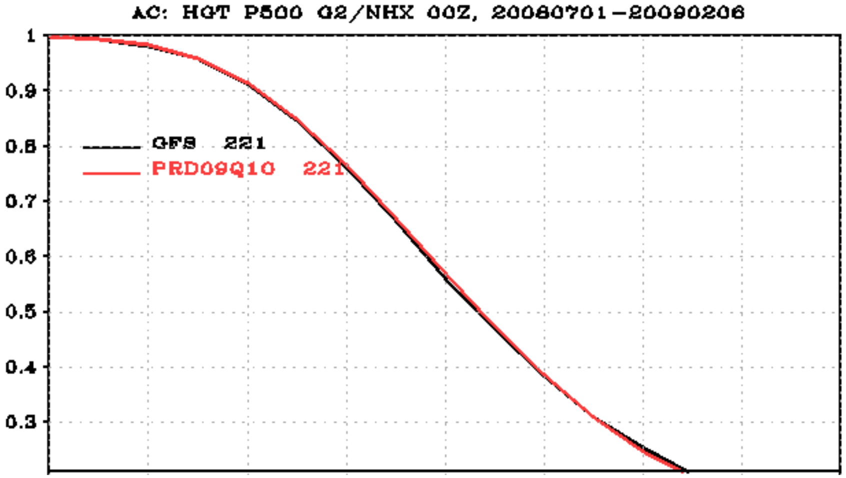
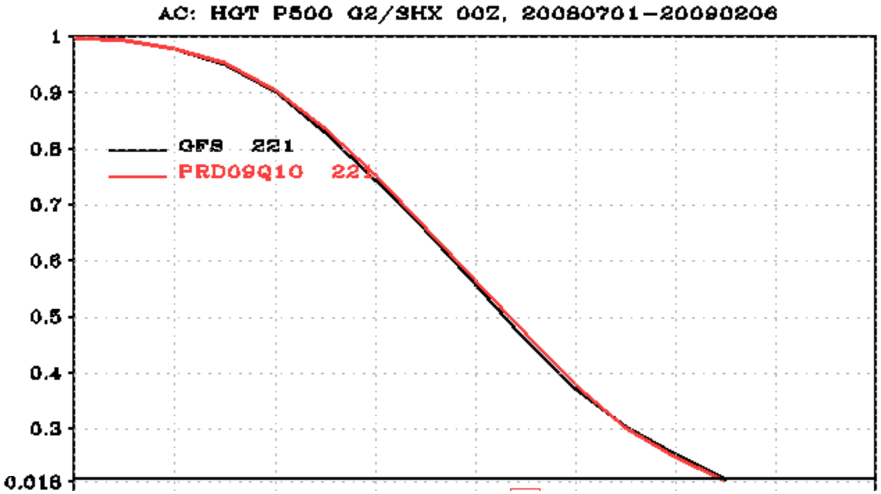
500 hPa Anomaly Correlation





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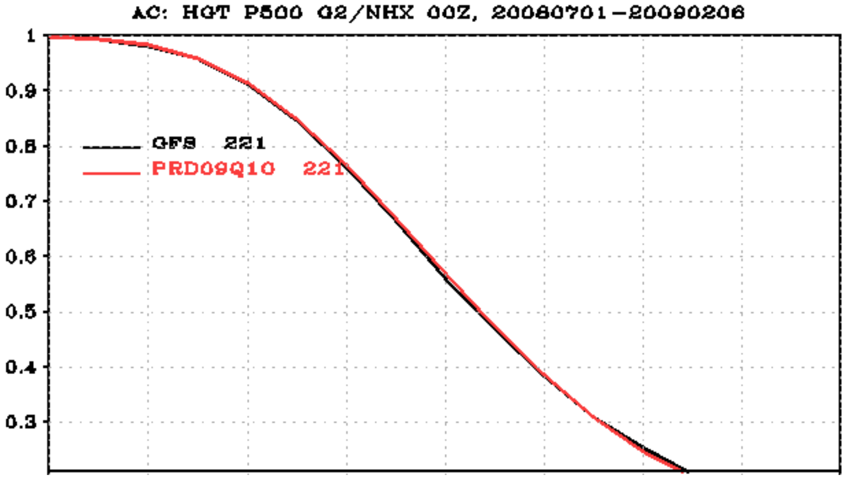
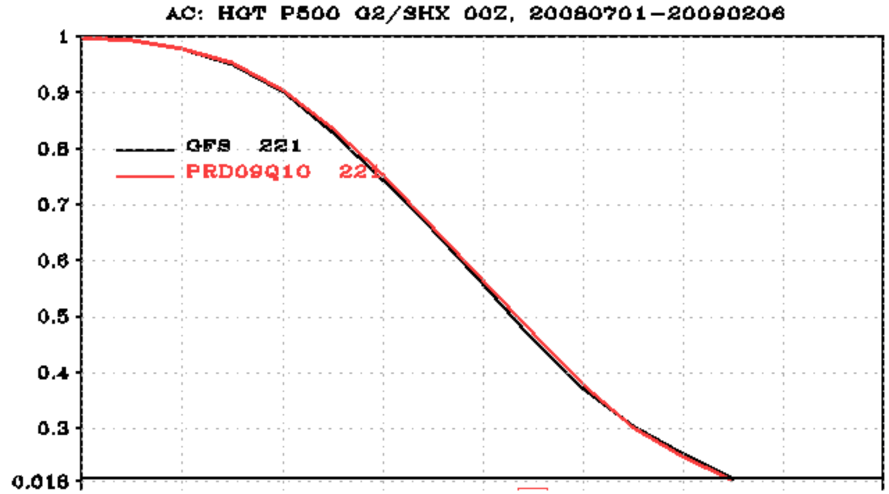
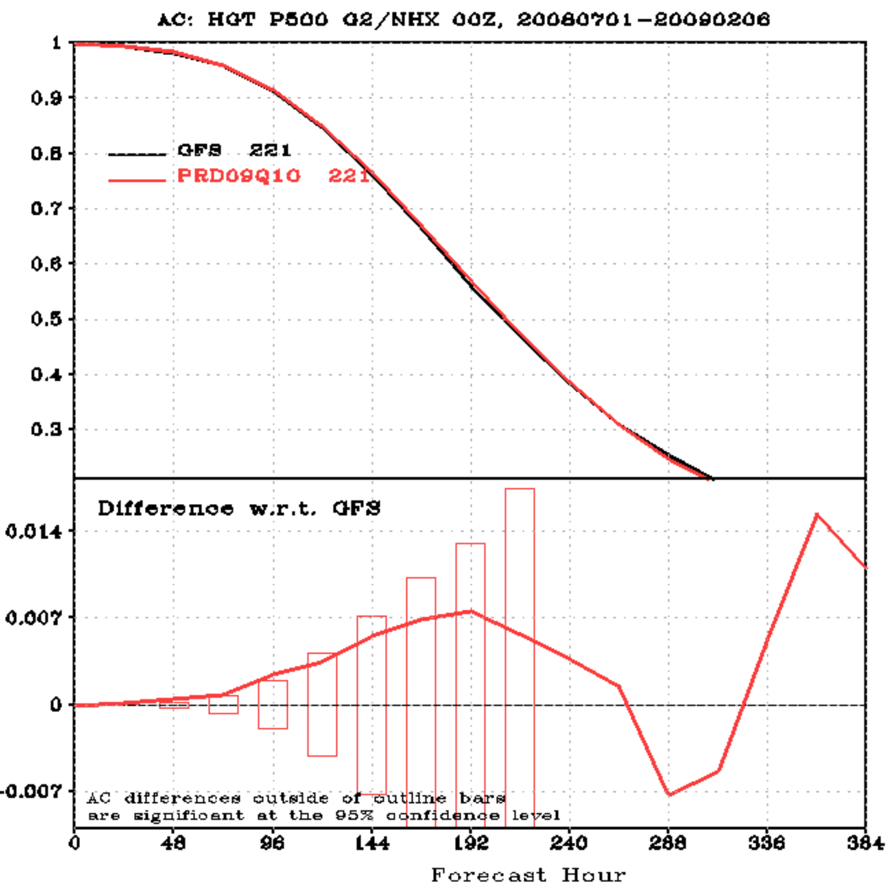
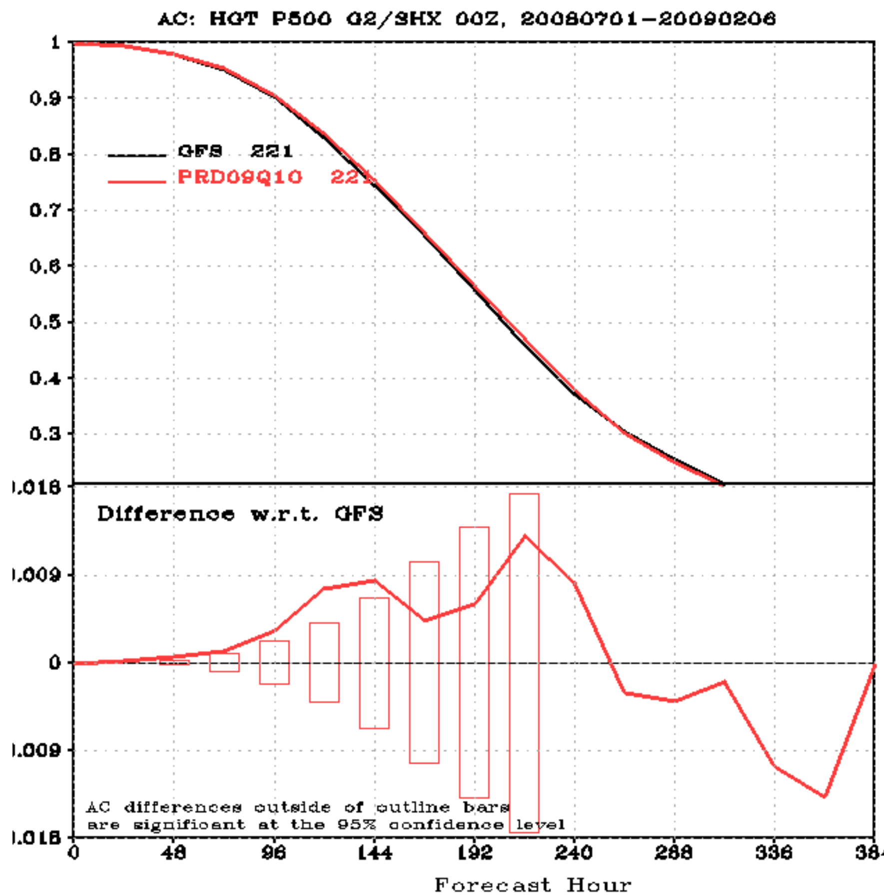




- "But these are just 'width of the line' improvements…"
- Why are these "improvements" important to users?
- Users don't live at 500 hPa, so what about sensible weather elements (precipitation, 2 m T, 2 m Td, max-min T)?

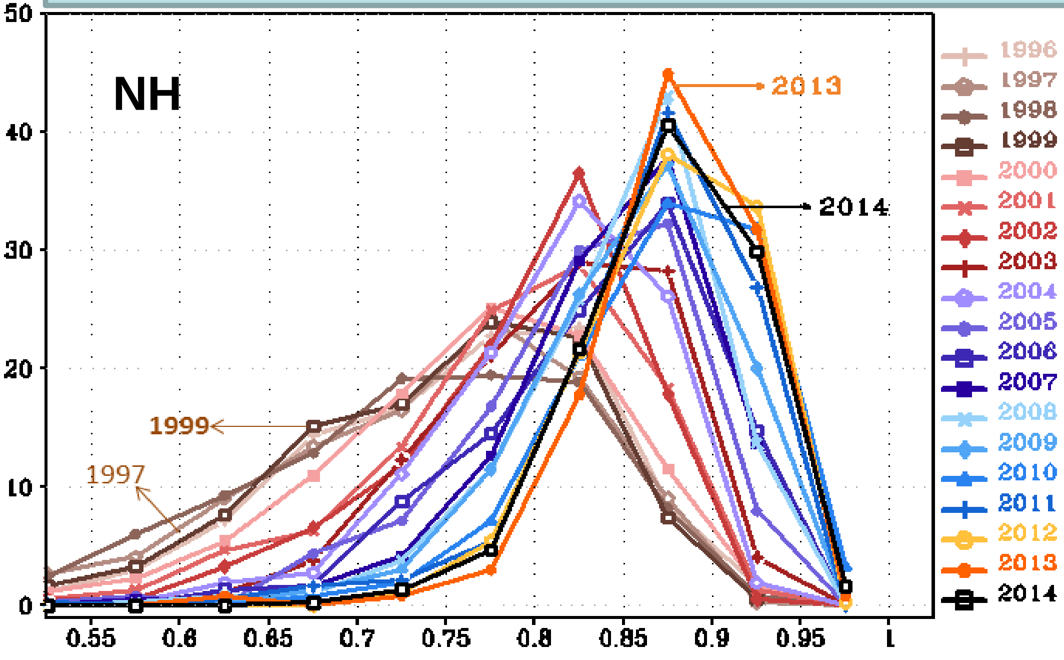
500 hPa Anomaly Correlation (Z500AC)



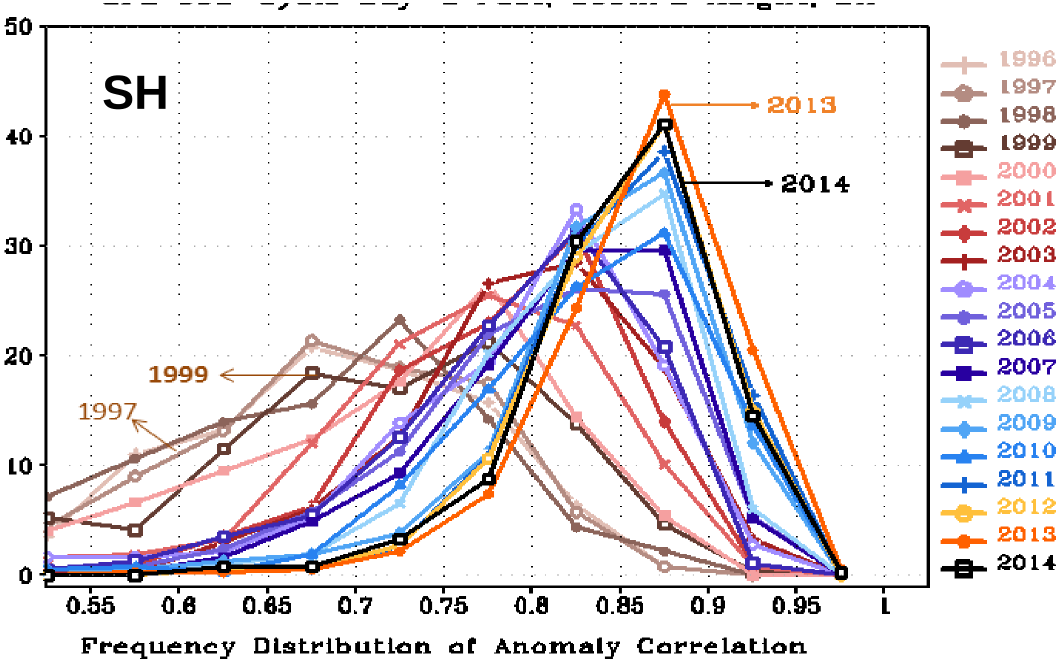


- **"These differences are statistically significant…"**
- Can users see the difference?

Frequency Distribution of Z500AC Scores (annual average 1997-2014)



- From one year to the next, changes may not be so apparent
- Over 5 years, changes are easily seen



- Changes are due to
  - Observations
  - System resolution*
  - Data assimilation techniques*
  - Model physics and dynamics*

*Made possible by more computing power

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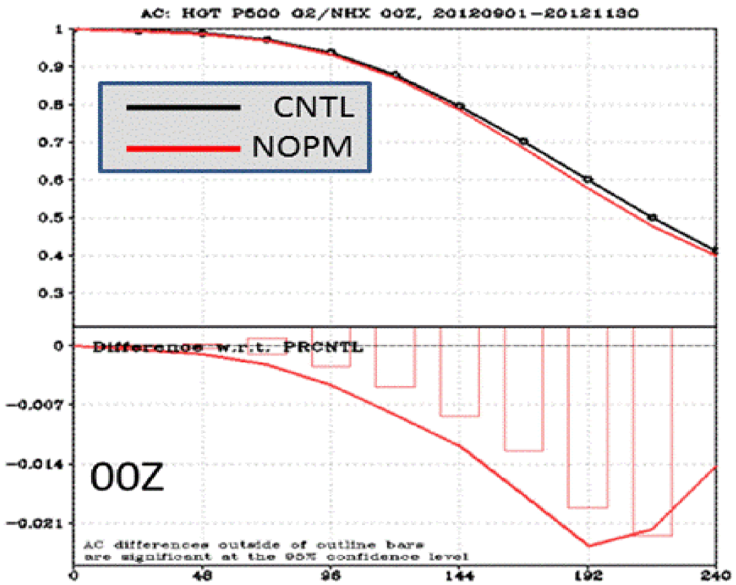
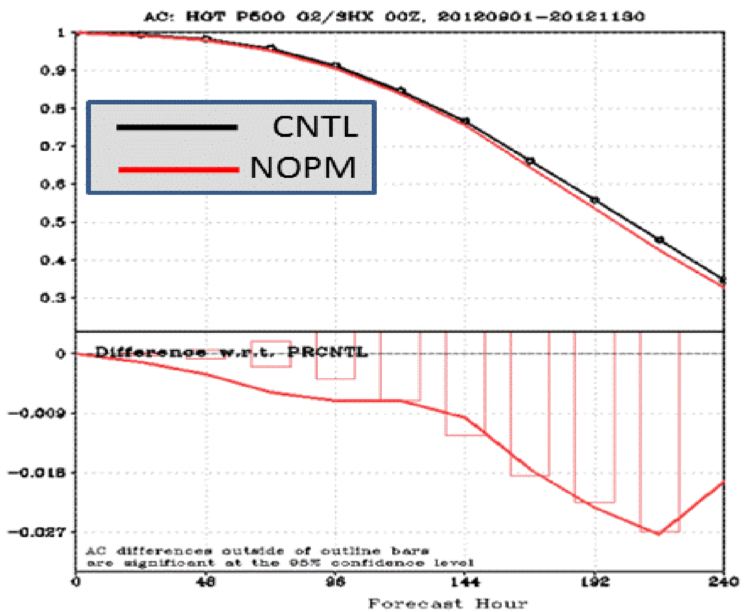
Z500AC Time Mean Results



5 Day (120 h)
Average Scores

CNTL: 87.5%
NOPM: 87.0%
Diff: 0.5%

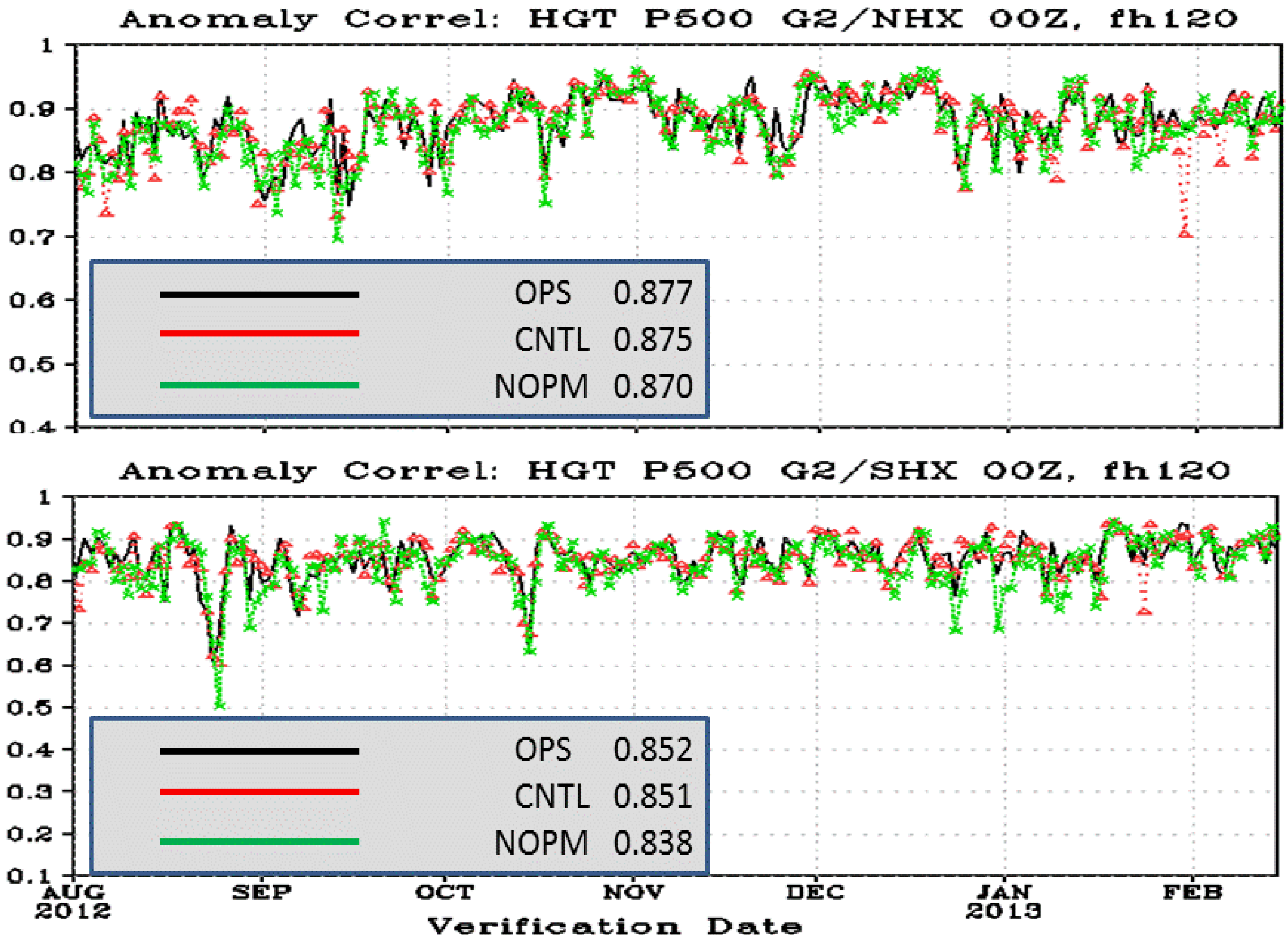
OPS: 87.7%



CNTL: 85.1%
NOPM: 83.8%
Diff: 1.3%

OPS: 85.2%

Z500AC Time History



What About Other Forecast Parameters?

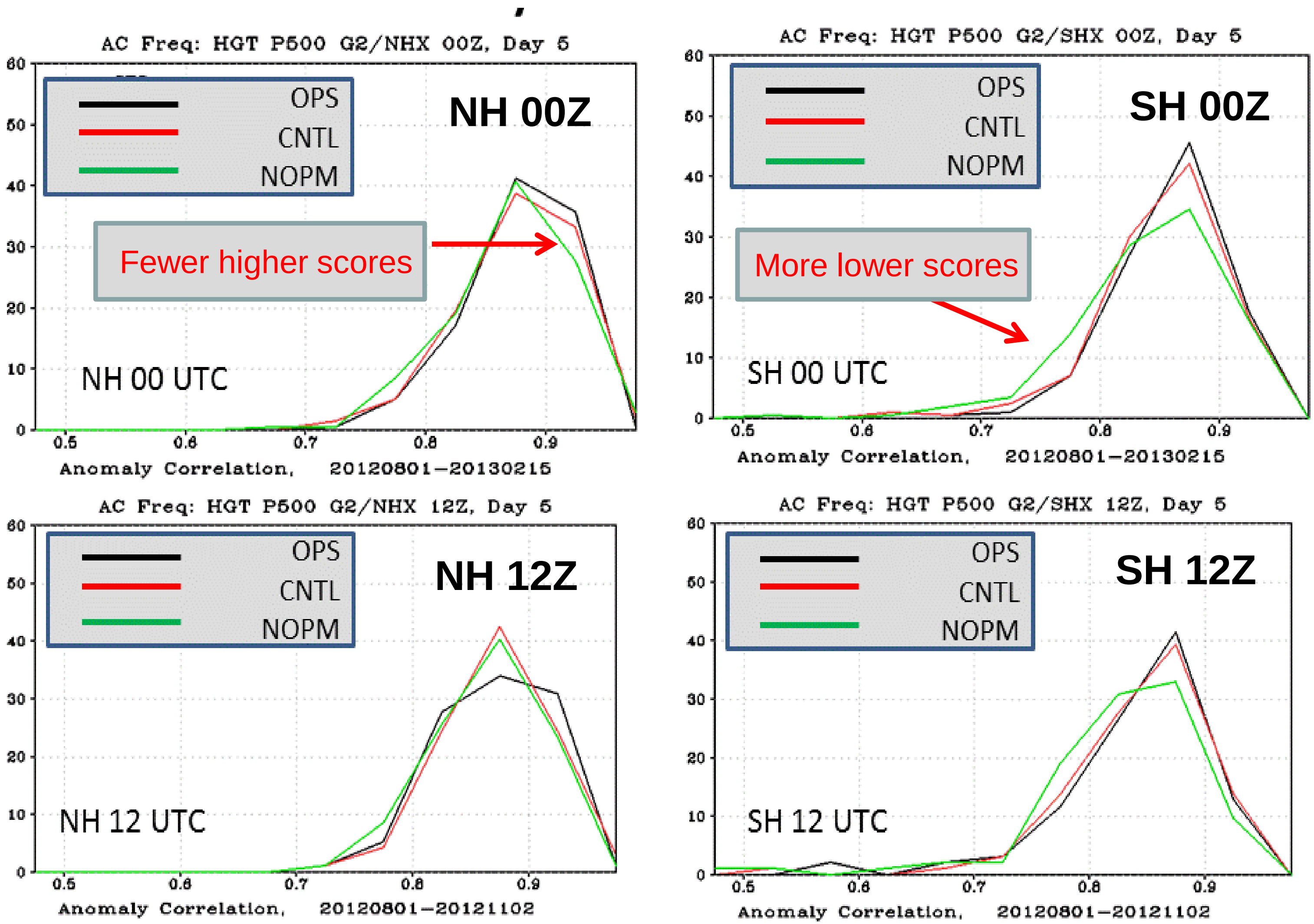
	August	SON	DJF
NH-Z500-AC			
NH-MSLP-AC			
NH-T-RMS-GRD			
NH-W-RMS-GRD			
CONUS PRC 24-48h			
CONUS PRC 60-84h			
TR-W-RMS-GRD			
HUR-TRK-ATL			N/A
HUR-TRK-EPAC			N/A
SH-Z500-AC			
SH-MSLP-AC			
SH-T-RMS-GRD			
SH-W-RMS-GRD			
NH-W-RMS-OBS 24-48h			
SH-W-RMS-OBS 24-48h			
TR-W-RMS-OBS 24-48h			
NA-W-RMS-Obs 24-48h			

CNTL vs NOPM

	CNTL better (Stat. Sig.)
	CNTL better (No Stat. Sig.)
	Neutral (No Stat. Sig.)
	NOPM better (No Stat. Sig.)
	NOPM better (Stat. Sig.)

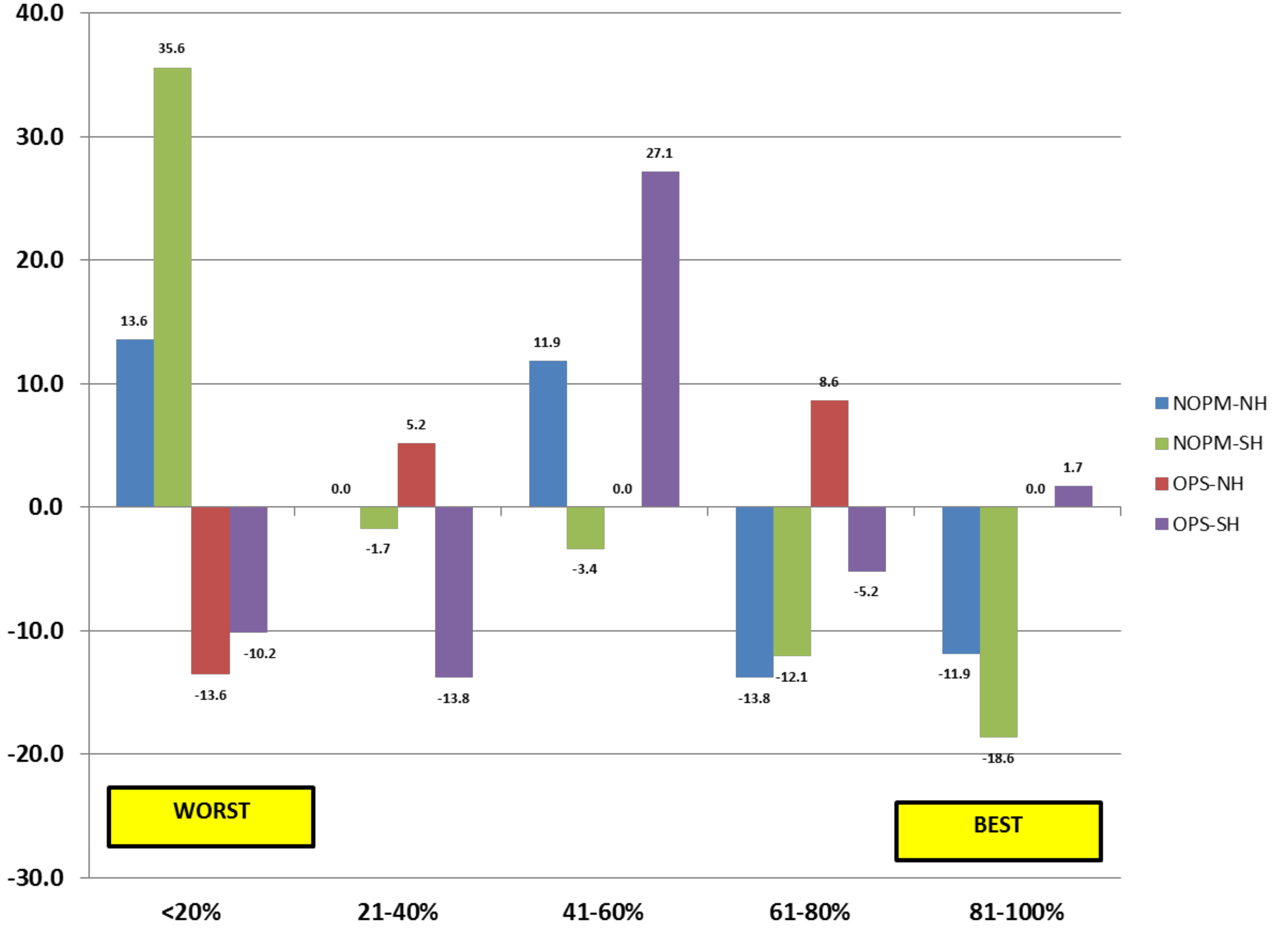
Value-added

Applying Frequency Distribution to OSE Results



Quantitative Results

- Compare NOPM and OPS distributions with Control



Summary (1)

- OSE designed and executed to measure impact of loss of JPSS PM orbit data in future satellite configuration

- Loss of PM data degrades average Z500AC score by statistically significant values of

  0.5% (NH) and 1.3% (SH)

- Consistent with other studies of its type

- Control slightly worse than OPS (not significant)

Summary (2)

- Compared to Control, NOPM is
  - 13.6% more likely to produce forecast score in lowest 20%ile in NH
  - 35.6% more likely in SH
  - 11.9% less likely to produce forecast score in the upper 20%ile in NH
  - 18.6% less likely in the SH
  - **Skewed toward producing more lower scores and fewer high scores**

- Compared to Control, OPS is
  - 13.6% less likely to produce score in lowest 20%ile in NH
  - 10.2% less likely in SH
  - **More resilient system with a small redundancy that does not increase forecast accuracy but does reduce possibility of a low score**

Thanks

Questions?

Observations 2012-2013 Conventional

	Type of data	Platform	Instrument/Measurement
Conventional			
	Soundings	Balloon	Radiosonde
		Ship	Radiosonde
		Pilot balloons (PIBALS)	Wind
		Profiler	Wind
	Commercial aircraft	MDCRS	Wind, temperature
		Canadian AMDAR	Wind, temperature
		European AMDAR	Wind, temperature
		Pilot reports	Wind, temperature
	Land surface	Airport surface data	Surface meteorology
		ASOS and AWOS	Surface meteorology
		Mesonets	Surface meteorology
	Marine	Ship	Surface meteorology, SST
		Moored buoy	Surface meteorology, SST
		Drifting buoy	Surface meteorology, SST
	Hurricane	Dropsondes	Wind, temperature, moisture, pressure
		Military reconnaissance data	Wind, temperature, moisture, pressure

Satellite Observations 2012-2013

Satellite	NOAA Polar-Orbiting Environmental System (POES)	NOAA-19	AMSU-A
			HIRS
			MHS
			AVHRR
			SBUV
		NOAA-18	AMSU-A
			MHS
			SBUV
		NOAA-17	HIRS
			SBUV
		NOAA-15	AMSU-A
	EUMETSAT (Polar-orbiting)	MetOp-A	IASI
			AMSU-A
			MHS
			HIRS
			GOME
			GRAS
			ASCAT
	NASA	Aqua	AIRS
			AMSU-A
			MODIS (AMVs)
		SNPP	ATMS
	GNSSRO	COSMIC-1	Radio Occultation
		TerraSAR-X	Radio Occultation
		GRACE-A	Radio Occultation
		SAC-C	Radio Occultation
		CNOFS	Radio Occultation
	NASA	Aura	OMI
	NOAA Geostationary Operational Environmental Satellite (GOES)	GOES-13 GOES-15	Sounder Sounder
			Imager (AMVs)
	EUMETSAT	METEOSAT-10	SEVIRI (Imager)
			SEVIRI (AMVs)
		METEOSAT-7	Imager (AMVs)
	JMA	MTSAT-2	Imager (AMVs)