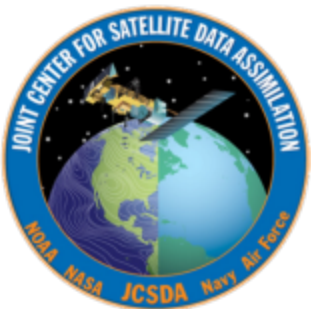




Optimization Of Sun-synchronous Orbital Planes; activities in the United States

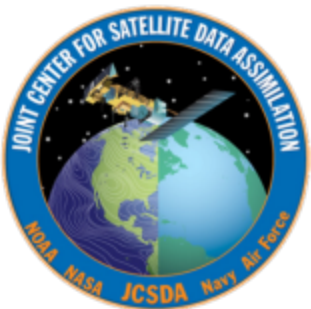
Lars Peter Riishojgaard

Director, Joint Center for Satellite Data Assimilation
Chair, OPAG-IOS, WMO Commission for Basic Systems



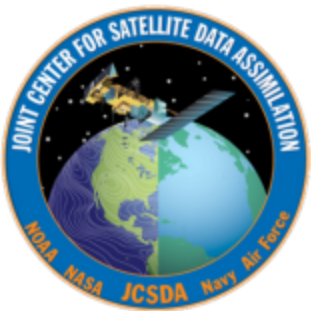
Overview

- Background; ***WMO Vision for GOS in 2025***
 - Coverage
- Case studies
- Past Data impact studies
- Current simulated data impact studies (“OSSEs”)
- Summary and Conclusion

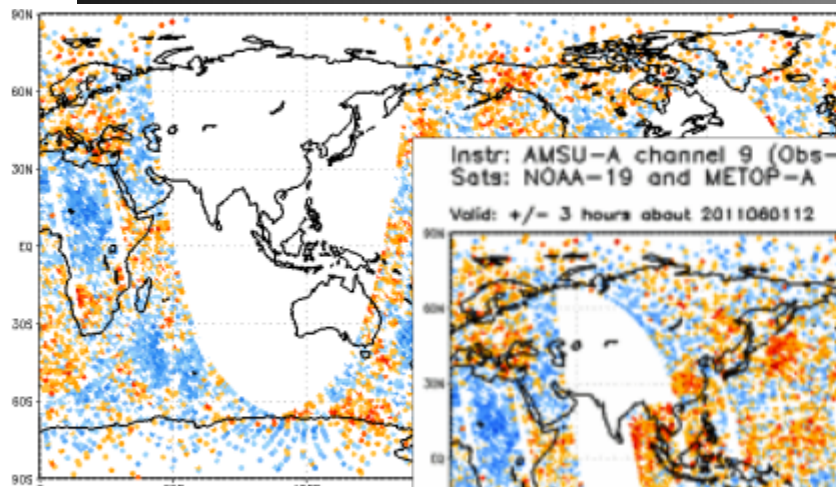


WMO Vision for the GOS in 2025

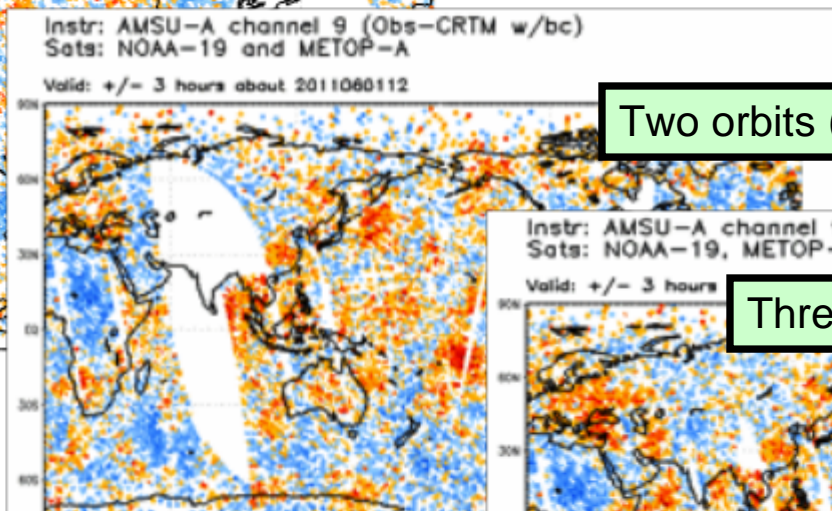
- ***"Operational polar-orbiting sun-synchronous satellites distributed within 3 orbital planes (~13:30, 17:30, 21:30 ECT)", each carrying "IR hyper-spectral sounders", "MW sounders"***
- This part of the ***Vision*** is now in jeopardy
 - No firm plans for early morning sounding missions
 - Some risk to continuity of PM sounding mission
- Q: What is the current basis of the requirement for sounding from three separate orbital planes?



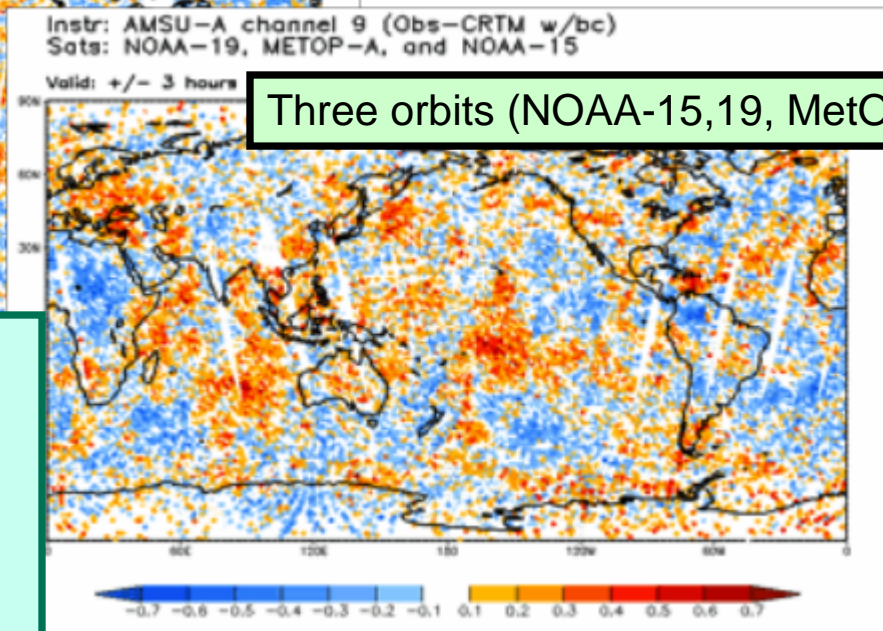
6-h data coverage example (AMSU-A)



One orbit (NOAA-19)



Two orbits (NOAA-19, MetOp-A)



Three orbits (NOAA-15, 19, MetOp-A)

Three orbits provide complete and consistent data coverage every 6h (consistent forecast solutions from cycle to cycle)

NCEP Data Denial Study Summary

(No Polar Satellite in P.M.Orbit)

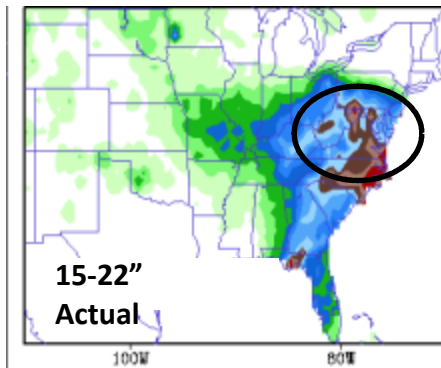
Case Study	Findings
Case 1: “Snowmageddon” Storm February 2010	Data denial runs significantly degraded; Experiment predicted a less intense storm, slightly further east and producing ½ of precipitation at 5, 4, 3 days before the event; in DC and Mid-Atlantic coast, model data denial runs did not forecast this paralyzing event and under-forecasted snow by at least 10 inches
Case 2: NYC and Blizzard December 2010	Data denial runs significantly degraded; Experiment under-predicted the storm that hit the NY area. The coastal low pressure was much weaker and the storm track was shifter further to the east well offshore of the NYC and New England areas resulting in less precipitation and snowfall for the area at 5, 4, 3 days before the event
Case 3: Northern Pacific Alaskan Coastal Storm – April 2011	Data denial runs largely unchanged
Case 4: Tornado Outbreak April 14-16, 2011	Data denial runs largely unchanged
Case 5 – Tornado Outbreak April 25-28, 2011	Data denial runs largely unchanged
Case 6 – Hurricane Irene August 2011	Data denial runs largely unchanged
Case 7 – Hurricane Katia August 2011	Data denial runs produced a slightly degraded forecast; the track and center of the storm was consistently further East than the Operational forecast

Case Study 1: “Snowmageddon”

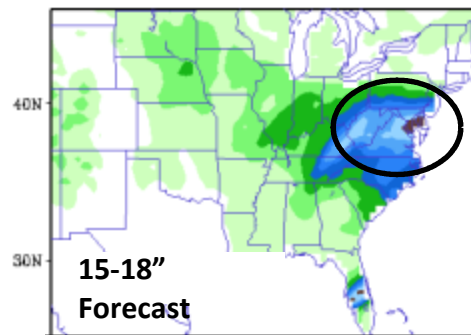
February 6, 2010

Forecast comparison using NOAA’s Polar-orbiting Operational
Environmental Satellite Data

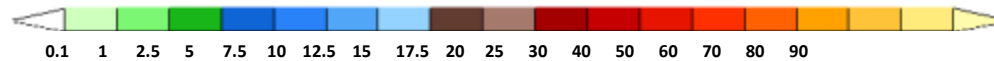
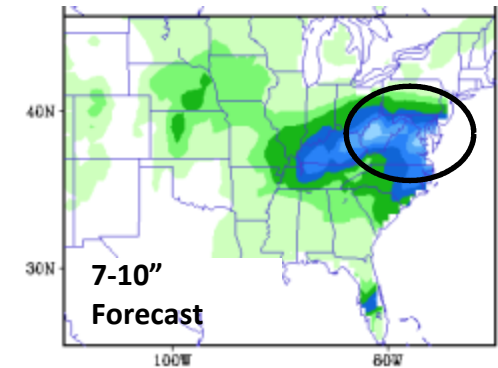
Observed Snowfall



5 day forecast with all NOAA
orbiting satellite data



5 day forecast without NOAA
afternoon orbiting satellite data



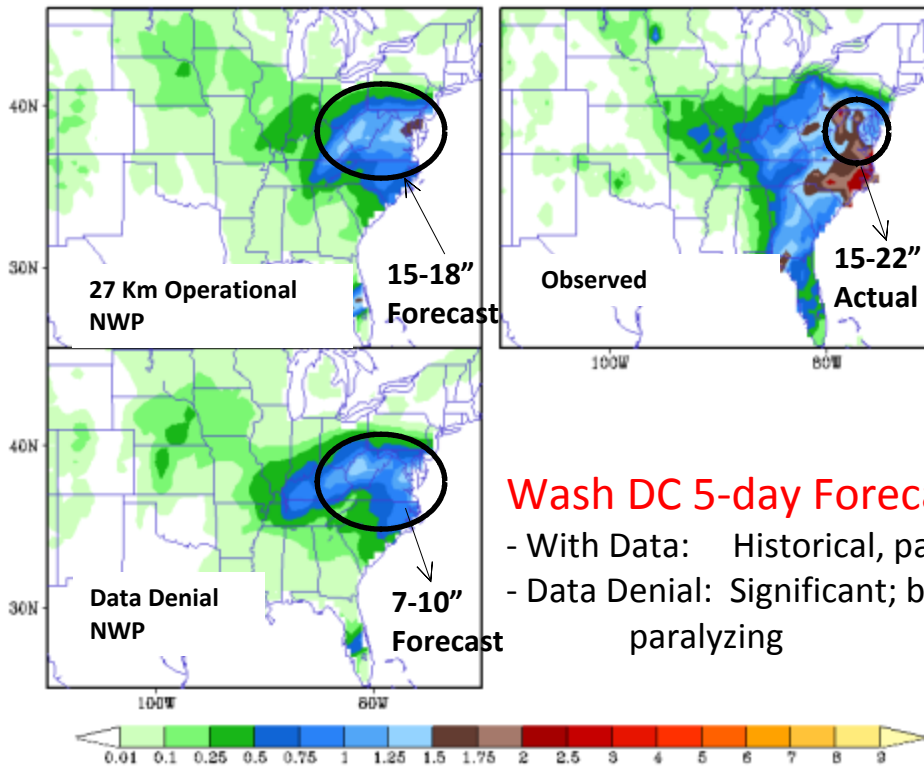
24 Hr Accumulated Snowfall Totals (inches) for 6
Feb (am)

Result: In DC and Mid-Atlantic coast, models without NOAA orbiting satellite data did not forecast this paralyzing event and ***under-forecast snow by at least 10 inches***
Impacts: Aircraft and airline passengers would have been stranded, ground commerce would have been halted with no mitigation plans, population would have been unprepared for paralyzing snow-depth

Results

24 Hr Accumulated Precipitation Totals for 6 Feb (am) 5 Day Forecast

Forecast Period: 5 Feb (am) – 6 Feb (am)



Wash DC 5-day Forecast:

- With Data: Historical, paralyzing event
- Data Denial: Significant; but not paralyzing

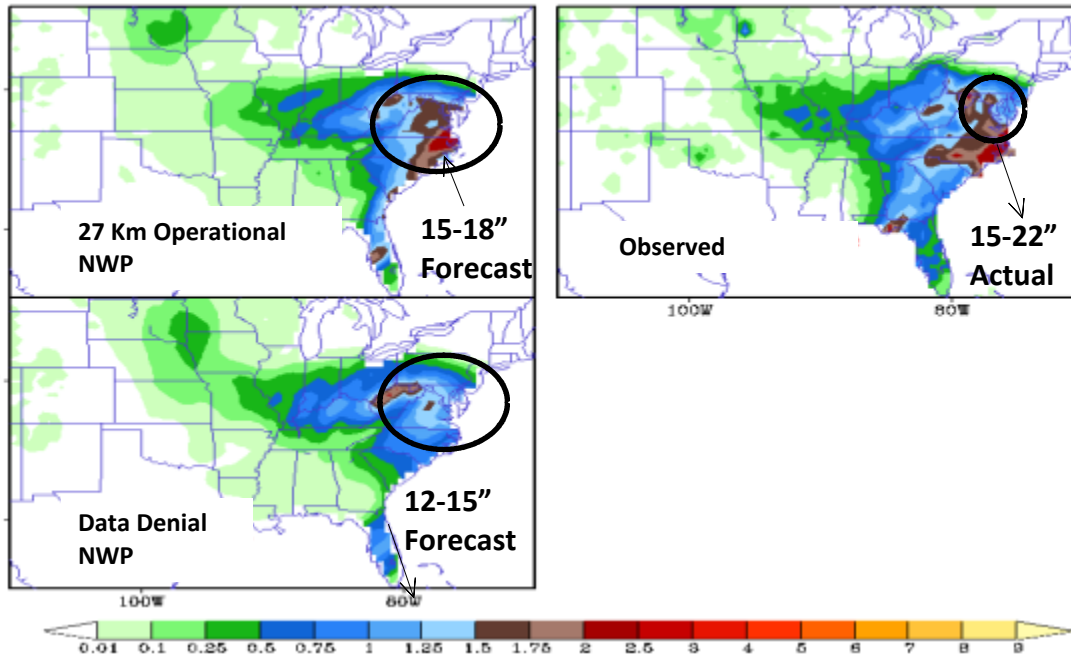
- 6 Feb: Models without PM data under-forecasted snow totals:
 - Operational forecast shows paralyzing event
 - Data Denial
 - Did not forecast paralyzing event in DC— at least 10" too low at Day 5
 - Low confidence in extreme snowfall at this point
 - Future errors of this scale could result in:
 - Aircraft and airline passengers stranded
 - Ground commerce halted with no mitigation plans
 - Population unprepared for paralyzing snow-depth

Results

24 Hr Accumulated Precipitation Totals for 6 Feb (am)

4 Day Forecast

Forecast Period: 5 Feb (am) – 6 Feb (am)



- 6 Feb: Models without PM data under-forecasted snow totals:
 - Operational forecast still superior
 - Increasing confidence in the forecast for major snow event
 - Data Denial forecast
 - Some improvement in snow forecast in DC area
 - Still under-forecasting total precipitation maximum in VA and Carolinas by 50%

Wash DC 4-day Forecast:

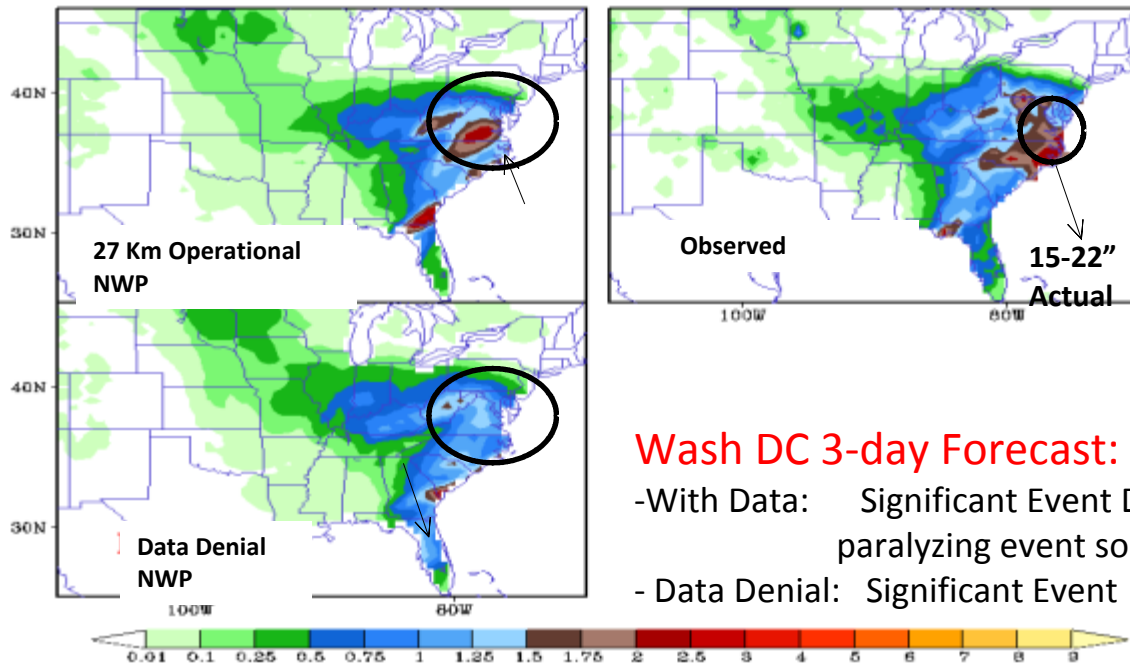
- With Data: Historical, paralyzing event
- Data Denial: Significant event

Results

24 Hr Accumulated Precipitation Totals for 6 Feb (am)

3 Day Forecast

Forecast Period: 5 Feb (am) – 6 Feb (am)



Wash DC 3-day Forecast:

- With Data: Significant Event DC; paralyzing event south
- Data Denial: Significant Event

- 6 Feb: Models without PM data under-forecasted snow totals:

– Operational forecast

- Shows lower snowfall totals in DC and surrounding area than previous model run but still superior to data denial
- Paralyzing event just south of DC
- Confidence in forecast for a major snow event still high

– Data Denial

- Lower forecast snowfall totals – decreased confidence in extreme event affecting Delmarva area
- Still under-forecasting total precipitation maximum in VA and Carolinas by 50%

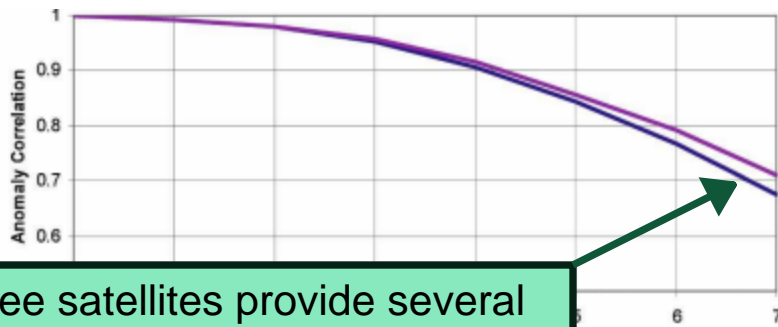


2. JCSDA/NCEP data denial studies

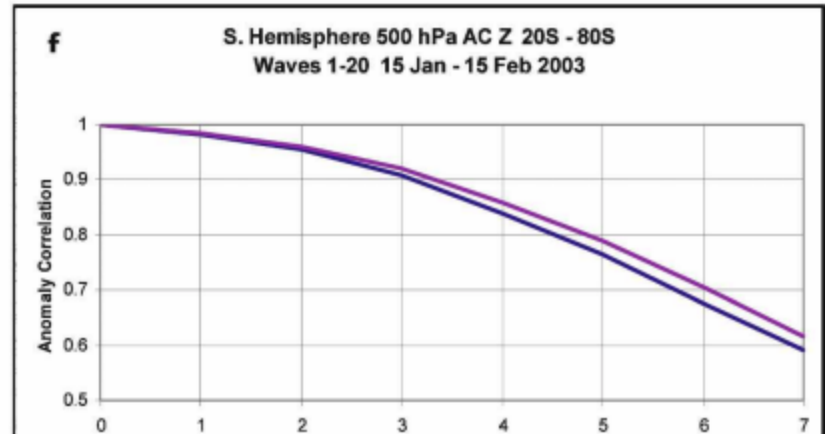
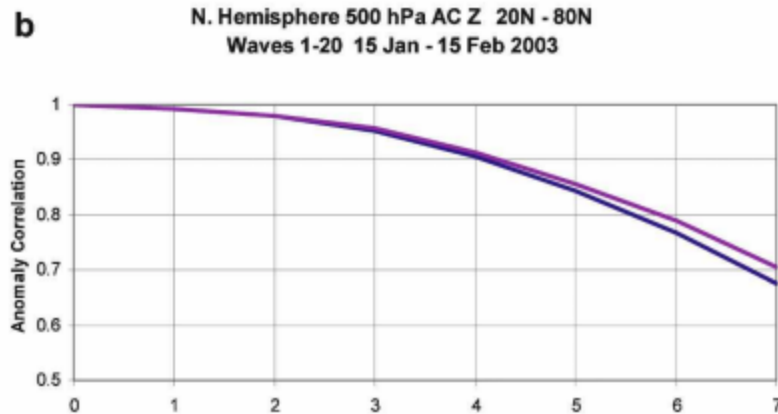
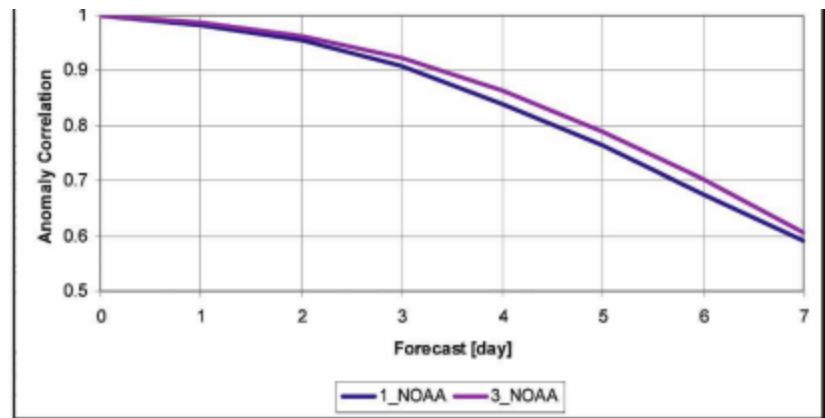
- NCEP operational GFS; 2005 version, based on GSI, horizontal resolution of T-256
- Experimental periods Jan-Feb and Aug-Sep 2003
- All operational data used in all experiments, except for polar LEOs:
- Three experiments using one, two or three AMSU-A sensors, respectively, in relatively well-separated orbits (NOAA-15, 16, 17)



JCSDA/NCEP 2003 Data Denial results (I)

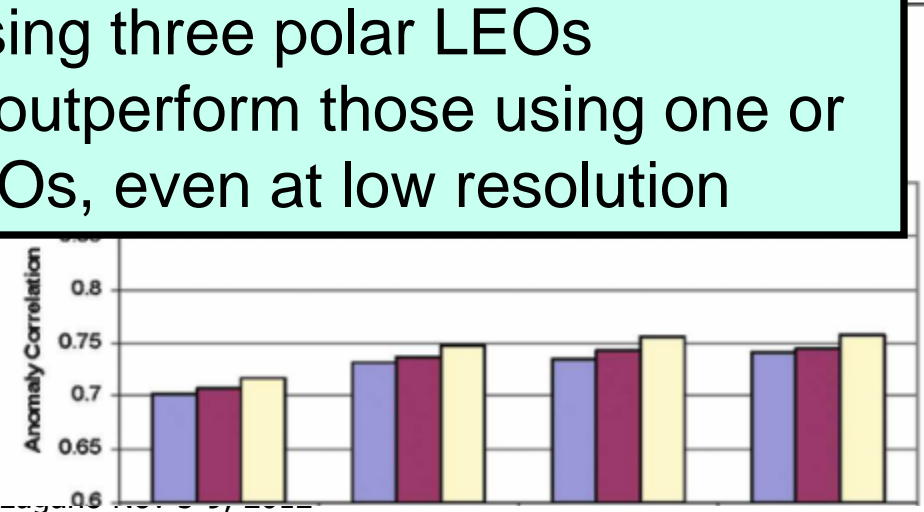
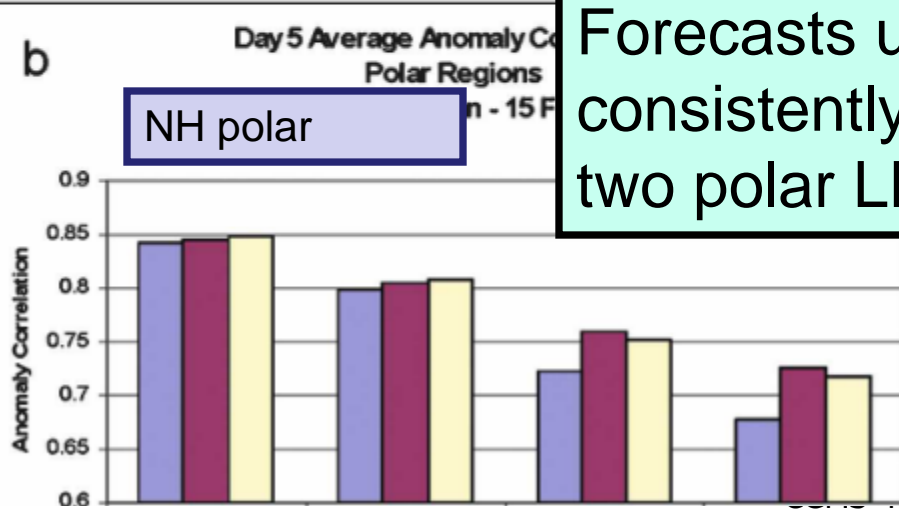
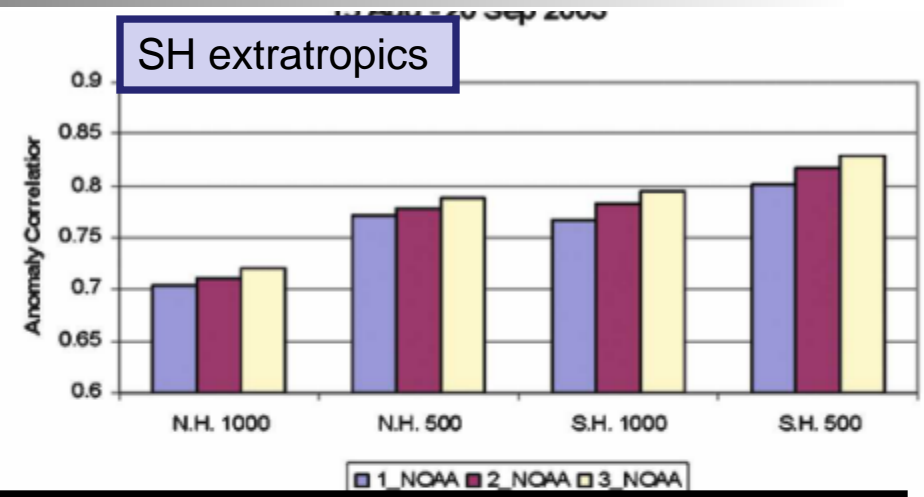
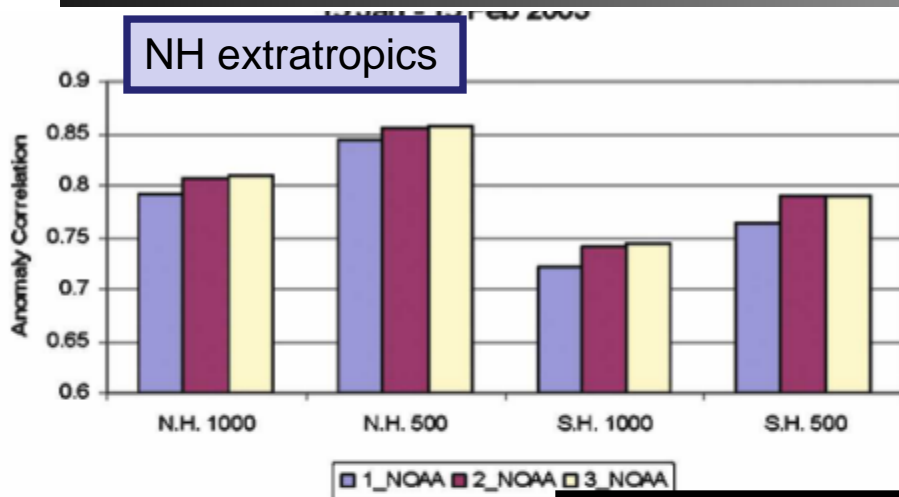


Three satellites provide several hours of extra forecast skill even averaged in time and space

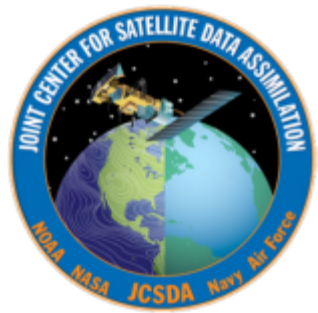




JCSDA/NCEP 2003 Data Denial results (II)

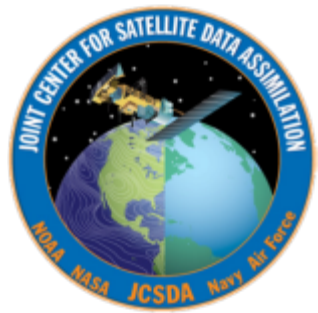


Forecasts using three polar LEOs consistently outperform those using one or two polar LEOs, even at low resolution



3. Current JCSDA OSSEs

- Based on 2011 version of NCEP GFS
- Reference observing system (simulated) is based on the current (2012) GOS, including hyperspectral IR and GPSRO
- Perturbation observations include a range of options for the early morning orbit
 - No data; SSMI/S; VIIRS (polar winds); CrIS+ATMS
- Preliminary results before the end of 2012; final results by April 2014



Summary and Conclusions

- Requirement for three well-separated orbital planes well supported by evidence from experiments undertaken by the United States
- Episodic impacts can be significant, consistent with Met Office theoretical study
- Broad data denial experiments now nearly ten years old; GOS, NWP systems have changed
 - New experiments using a modern NWP system, updated horizontal resolution and the current GOS currently underway