

On the Cost and Benefits of Meteorological Satellite Systems

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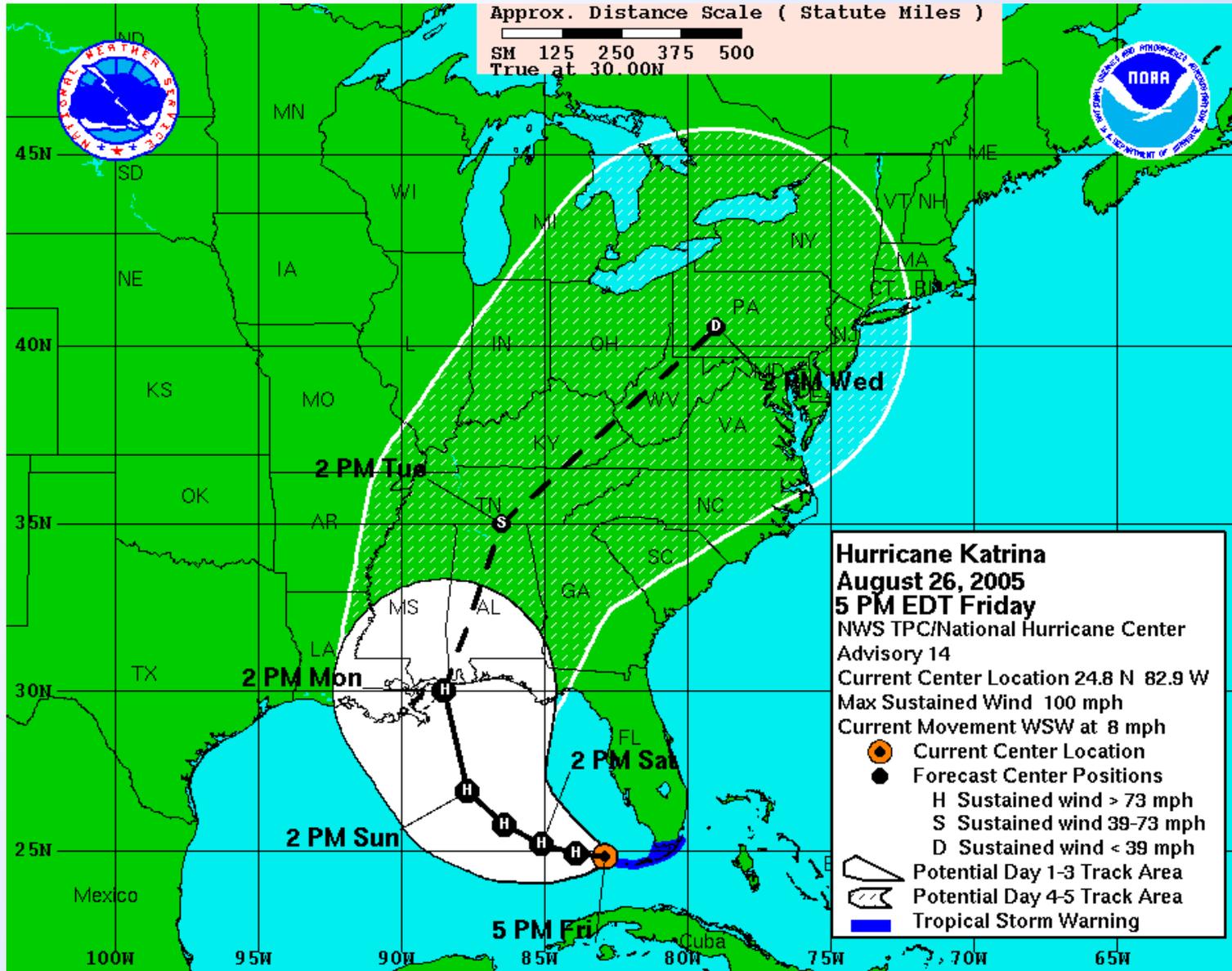
Overview

- A quick look at money and weather forecasting
 - Anecdotally: A tale of two hurricanes
 - Macroscopically: weather, weather forecasting and the US economy
- Enabling capabilities for weather prediction
 - Role of NWP and NWP diagnostics
- Impact of satellite data
- A dollar value on observations?

A Tale of Two Hurricanes

- Galveston Hurricane
 - Landfall in Texas at 5 PM 09/08/1900
 - > \$500M (2008 dollars) in property damage
 - ~10,000 fatalities (out of a population of ~40,000)
 - No satellite data, no upper air network, no NWP
 - Estimated Category 4 at landfall
- Katrina
 - Landfall (2nd) in Louisiana at 6 AM 08/29 2005
 - > \$90B in property damage (2008 dollars)
 - > 1800 fatalities (out of a population of ~1.5M)
 - Extensive satellite and conventional observations, good forecast
 - Category 3 at Landfall

Hurricane Katrina Track



Weather Prediction and the US Economy: A Macroscopic View

- Department of Commerce: “20% of overall US economy is weather sensitive”: *~\$3 trillion/year*
 - Impact to air and surface transportation, agriculture, construction, energy production and distribution, etc.
- Assume that half of this is “forecast sensitive”: *\$1.5 trillion/year*
- Assume that the potential savings due to weather forecasting amount to 5% of the “forecast sensitive total”: *~\$75B/year*

A Macroscopic View (II)

- Assume that the savings are distributed linearly over the achieved forecast range for the global NWP system:
 - 0 h useful forecast range => \$0 in savings
 - 336 h useful forecast (two weeks maximum predictability) range => \$75B in savings
- This implies that the value to the United States economy of weather observations, dissemination, forecast products and services is >200M per hour of forecast range per year !

The Global Picture

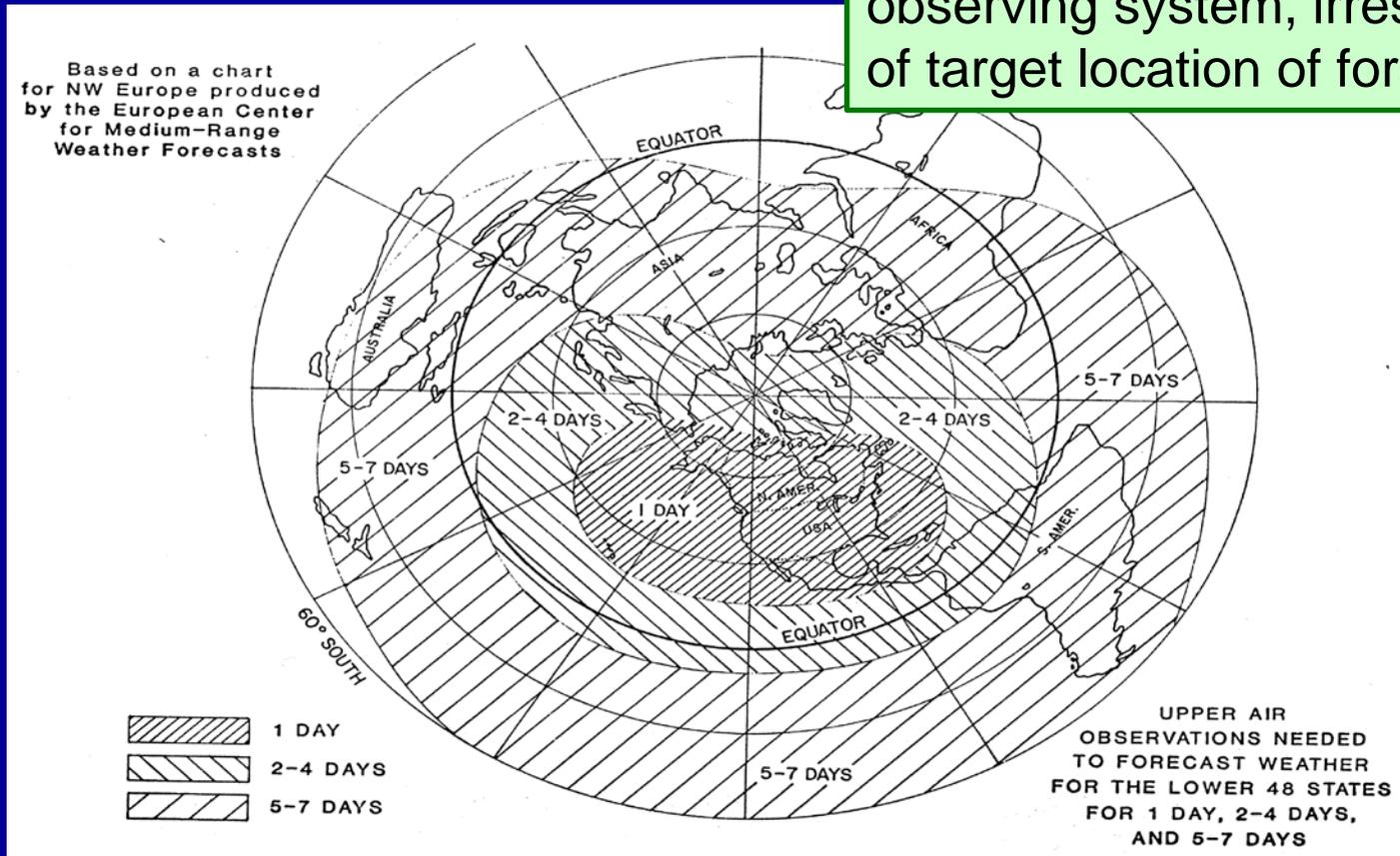
- The amount of \$75B/year is **one** estimate of the magnitude of the total potential socioeconomic benefit of weather prediction activities to the US economy
- Scaling exercise, using World Bank (2011) numbers:
 - Annual GDP of United States: ~\$15T
 - Annual GDP of all nations combined: ~\$70T
 - Assuming *on average* (i) equal sensitivity to weather, and (ii) equal potential benefits from ability to predict across all nations, we get an estimated **\$75B * (\$15T/\$70T) = \$350B** as the total global potential benefit of weather prediction activities (indicating a likely range of \$100B to \$1T)

Weather Prediction Enabling Capabilities

1. Observing Systems
 2. Dissemination Systems
 3. Numerical Weather Prediction
 - Science (modeling, data assimilation)
 - High-end computing
 4. Service Delivery
- 1, 2 and 3 are of a *foundational* nature, with **1** representing the single largest expenditure, and **3** providing a powerful diagnostics capability

NWP requirements for upper-air data coverage

Hence the need for a global observing system, irrespective of target location of forecast!

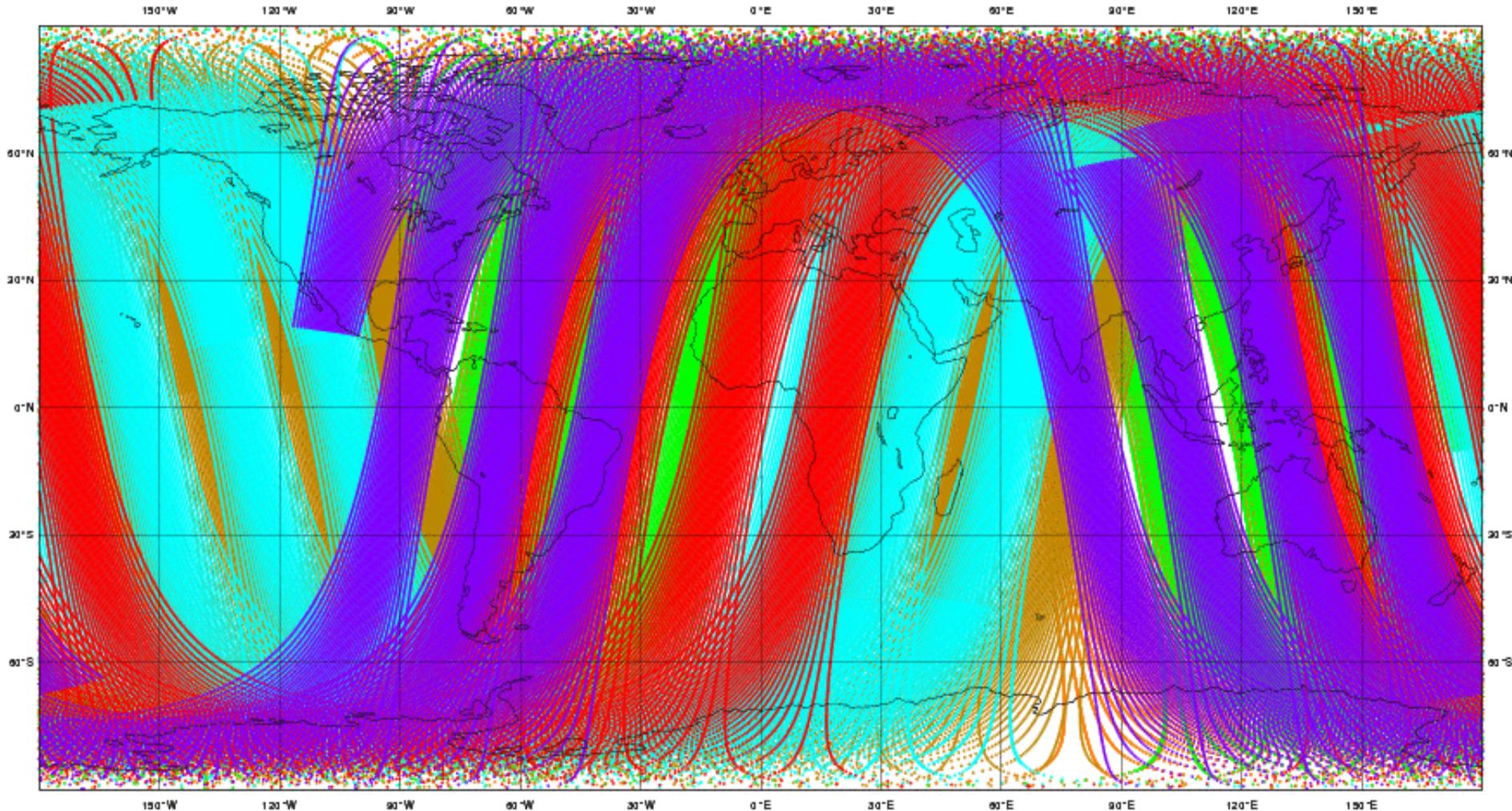


ECMWF Data Coverage (All obs DA) - AMSU-A

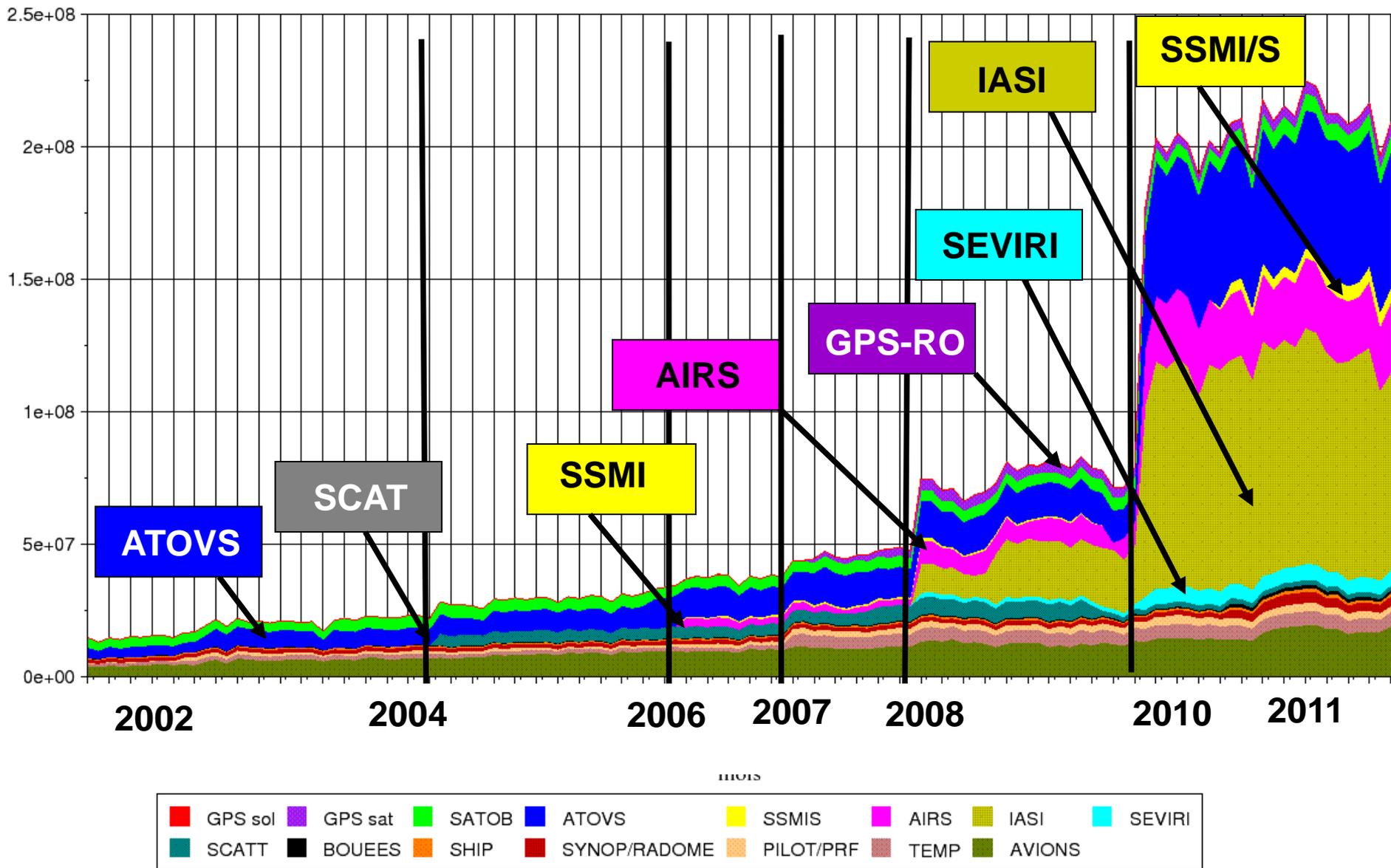
25/Jul/2012; 06 UTC

Total number of obs = 720247

- 106650 Noaa16
- 163413 Noaa18
- 118770 Metop
- 81750 Noaa15
- 0 Noaa17
- 78300 Aqua
- 171364 Noaa19

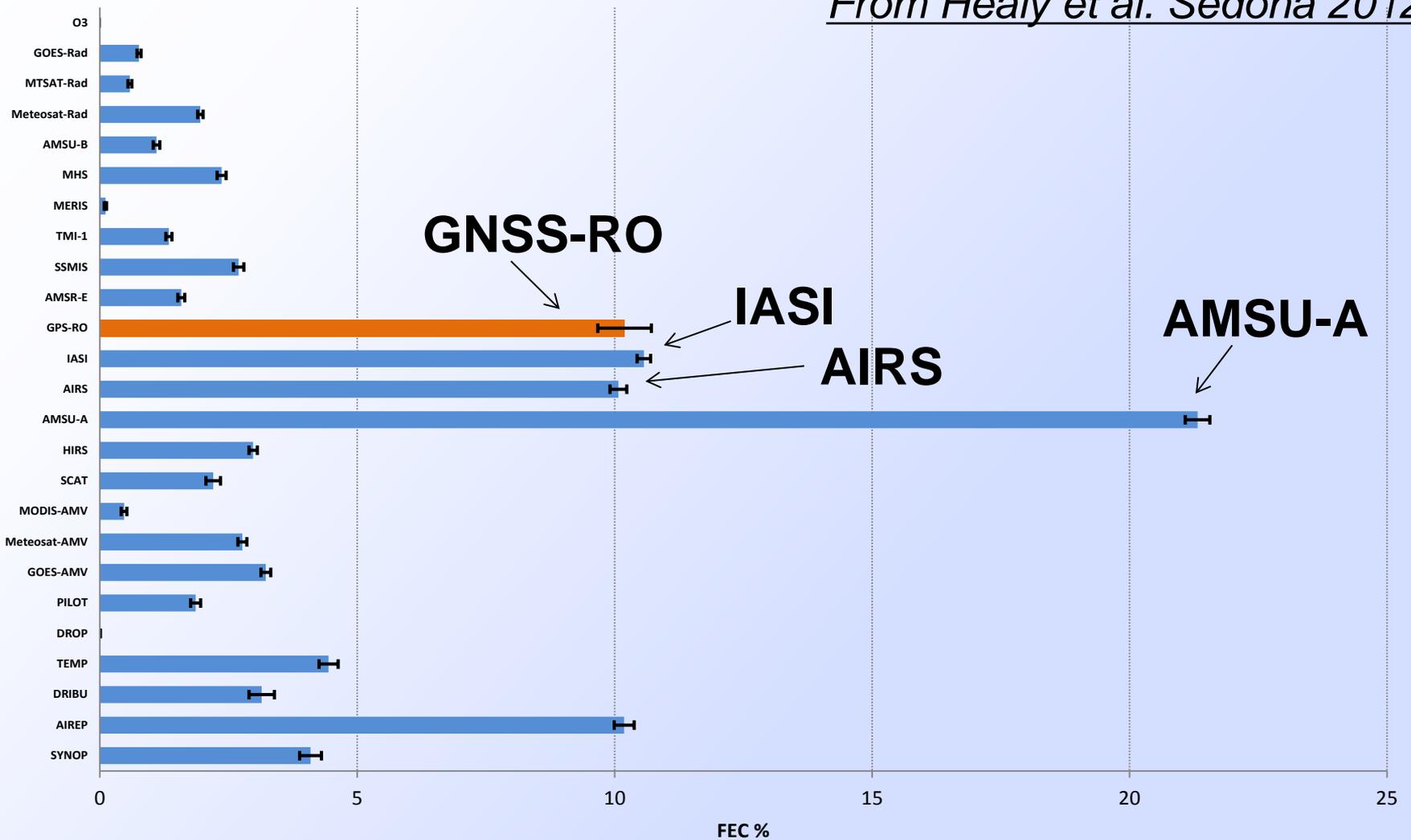


Monthly Mean of No. Of Observations Daily in Global Model



FSO: ECMWF System (June 2011)

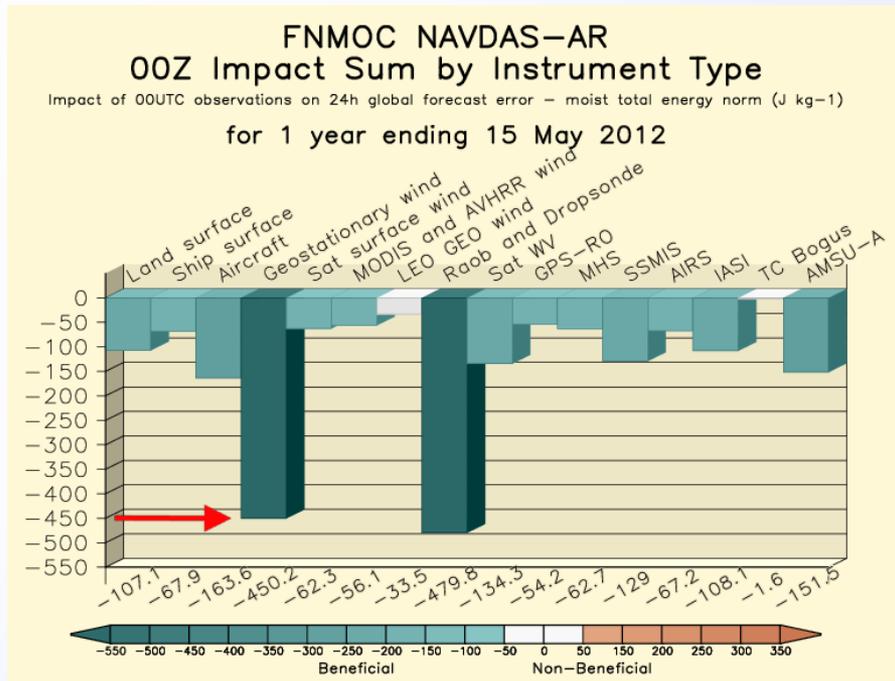
From Healy et al. Sedona 2012



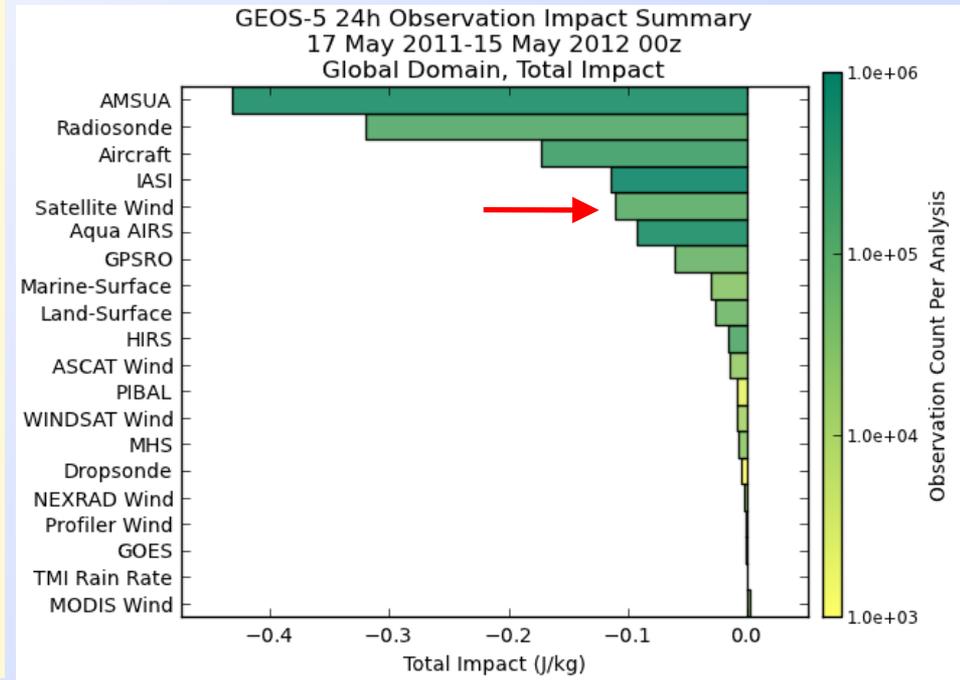
FNMOC and GMAO Observation Impact Monitoring

Current Operations

Gelaro et al. , Sedona May 2012



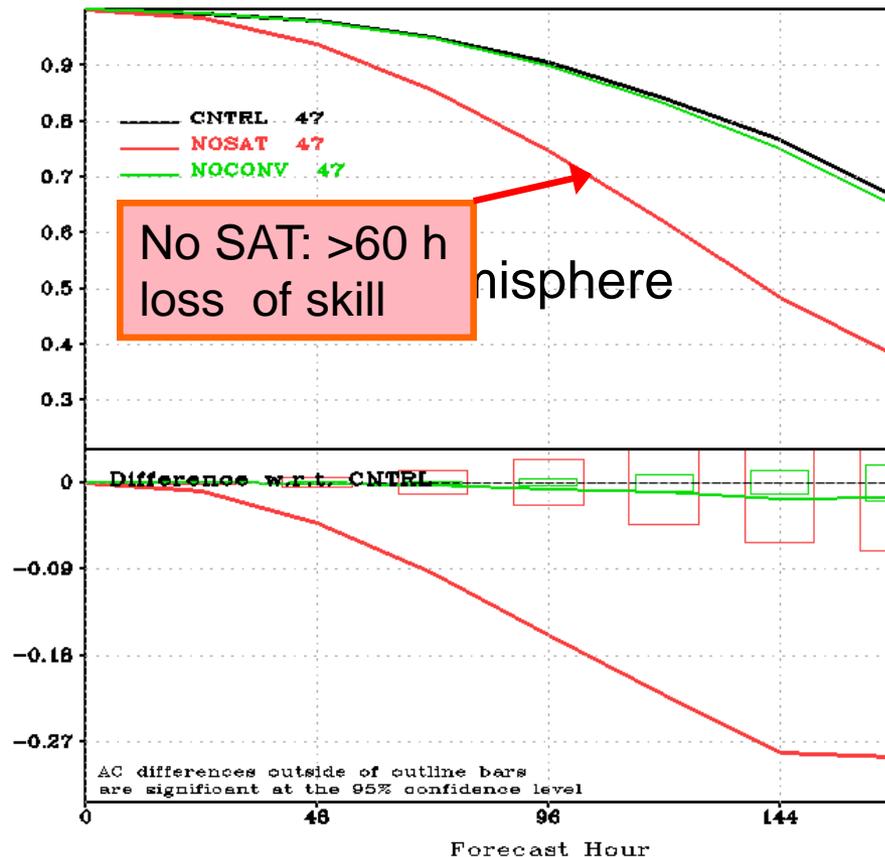
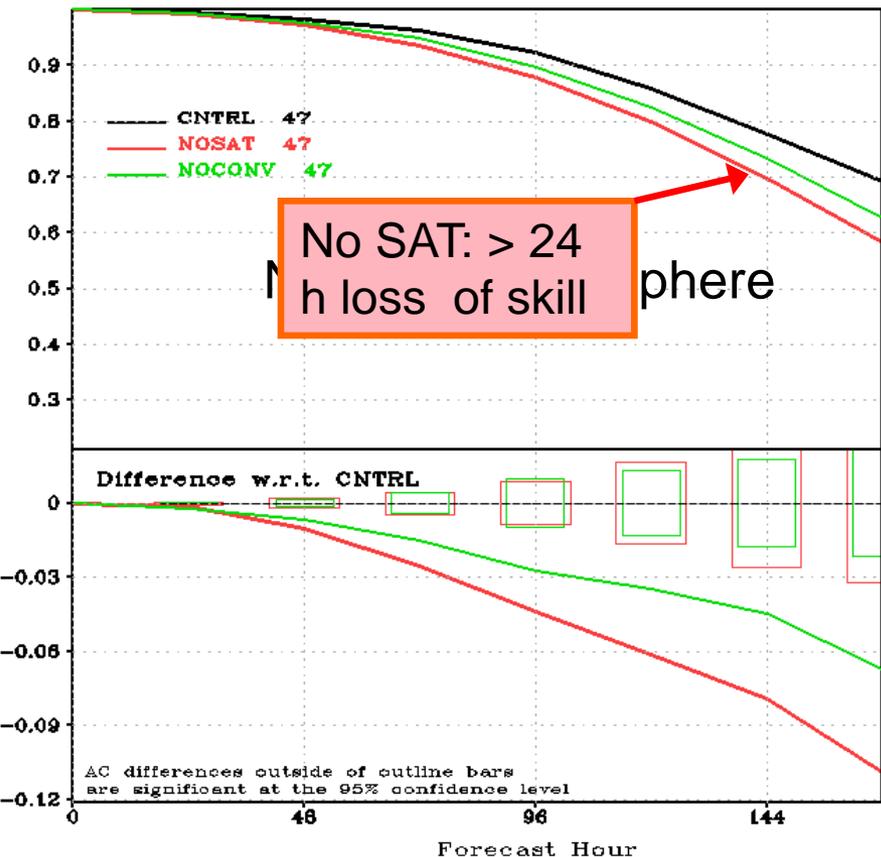
http://www.nrlmry.navy.mil/obsens/fnmoc/obsens_main_od.html



http://gmao.gsfc.nasa.gov/products/forecasts/systems/fp/obs_impact/



No Satellite / No Conventional Data



Jung, 5th WMO Impact Workshop, Sedona 2012)

Final remarks

- The economic impact of *weather* is at least somewhat recognized and understood
 - In contrast, the economic impact of *weather prediction* is generally not well studied and documented
- The cost of obtaining meteorological observations is generally understood only at the national level; no reliable cost estimates available at the global level
 - Assessment of the monetary value of meteorological observations is even less developed
 - By a rough estimate, the value to US economy likely in the range of \$5B/year or more for NWP alone; this does not measure the value of direct forecast applications, of climate, ocean, land surface, atmospheric composition measurements, or of improved scientific understanding