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

10th Symposium on Environmental Satellites
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 \times \left( \frac{$15T}{$70T} \right) = $350B$ 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
Monthly Mean of No. Of Observations Daily in Global Model
From Healy et al. Sedona 2012
FNMOC and GMAO Observation Impact Monitoring
Current Operations


Gelaro et al., Sedona May 2012
No Satellite / No Conventional Data

No SAT: > 24 h loss of skill

No SAT: > 60 h loss of skill

Jung, 5th WMO Impact Workshop, Sedona 2012)
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.