Measuring the Immeasurable:
Innovation and the Economic Benefits of Satellite Data

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Communicating to Multiple Stakeholders

- Increasing requirements to demonstrate value of organizations and portfolios
- Need to balance stakeholder perspectives on what to measure and value
- The challenge: how to value R&D activities that are difficult to measure?

Developing Measures

o Previously, we developed a performance management system for STAR which suggested a framework and a range of metrics for managing research.

o Designed to not only help meet the report requirements of the Government Performance and Results Act (GRPA) and the Program Assessment Rating Tool (PART), but also to help better manage for innovation.

o Ongoing work with STAR to develop additional measures to address different perspectives and stakeholders. In this presentation:

- Internal Process – Innovation
- Customer – Economic Benefits

Internal Processes - Innovation

- A central concern for S&T managers is how to foster and facilitate innovative research
  - Yet there is little consensus about specific strategies.
  - Further, the measurement of types of innovation, such as radical or incremental and product or process, too often remains undefined.

- Initially, we attempted to document the history of innovation at STAR
  - Publication, citations, new products, new uses for products
  - Develop a timeline/time-series

- Aim was to discern any patterns between the rate of publication and the rate of innovations.
  - Difficulty of reliable information
    - Unable to locate an accurate record
    - Despite the importance of conference proceedings and posters, no reliable listing

- Timeline/time-series was impossible but a five year summary was possible

What's an Innovation?

- STAR serves two quite different communities, the scientific community and the various clients of NOAA

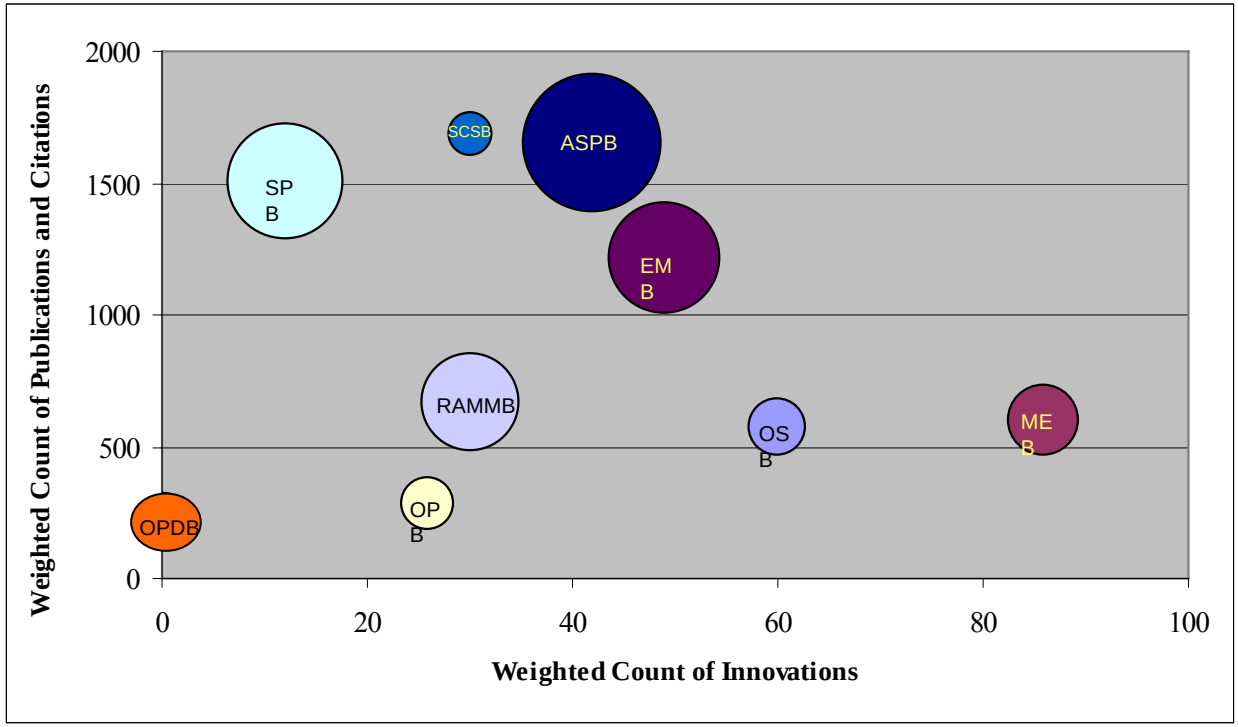
- Challenge with STAR was to analyze the respective contributions of product and scientific innovations
  - Definitional issues – what is a product?
  - At STAR, primarily an algorithm
    - For example, algorithm that provides data on stratospheric ozone from the Solar Backscatter Ultraviolet (SBUV) sensor
  - But also important to distinguish between new products and major/minor modifications – what is new?
    - For example, an existing product is reclassified as new if in fact new streams of information are added to it.

- What is a contribution to scientific knowledge?
  - Recognized issues with the use of publications
  - Conference papers and posters are also important, but not regularly tracked

Visualizing Innovation

- Wanted to visually present the relative contributions to science (publications) and product development (new products and modifications) using a bubble chart
  - Both products and publications represented a relevant dimension
  - Each dimension calculated along a sliding scale
  - Product innovation given a weight of 10, new uses 6 and upgrades 3.
    - Same logic applied to papers and citations
- Also tried to standardize the size of bubble
  - Size represents the proportion of all papers published by individuals relative to the total of STAR publications

Visualizing Innovation



- Illustrates a number of interesting relationships.
  - Satellite Climte Studies Branch (SCSB) had fewer publications than Advanced Satellite Products Branch (ASPB), but more citations
  - Ocean Sensors Branch (OSB) and Marine Ecosystems Branch (MEB) had fewer publications but more product innovations
  - Corresponds to the type of research conducted by each branch

Visualizing Innovation

- Based on this work, three primary recommendations
  - STAR needs to put in place a system that accurately records both all types of scientific contributions (publications, proceedings and posters) and innovations (new products, revised products, and new methods or processes).
  - Critical that the contributions of each individual and which branch they are assigned to be included.
    - The spread of networks in STAR means that giving exclusive credit to one branch is probably misleading.
  - Convene a small peer-review panel to vet the framework.

Customers/Users: Economic Benefits

- Apart from scientific contributions, what are the economic benefits of satellite data?

- Satellite data has been an important contributor to operational weather forecasts since 1960s, but use has greatly accelerated in the past decade

- Despite importance, need to justify public investment

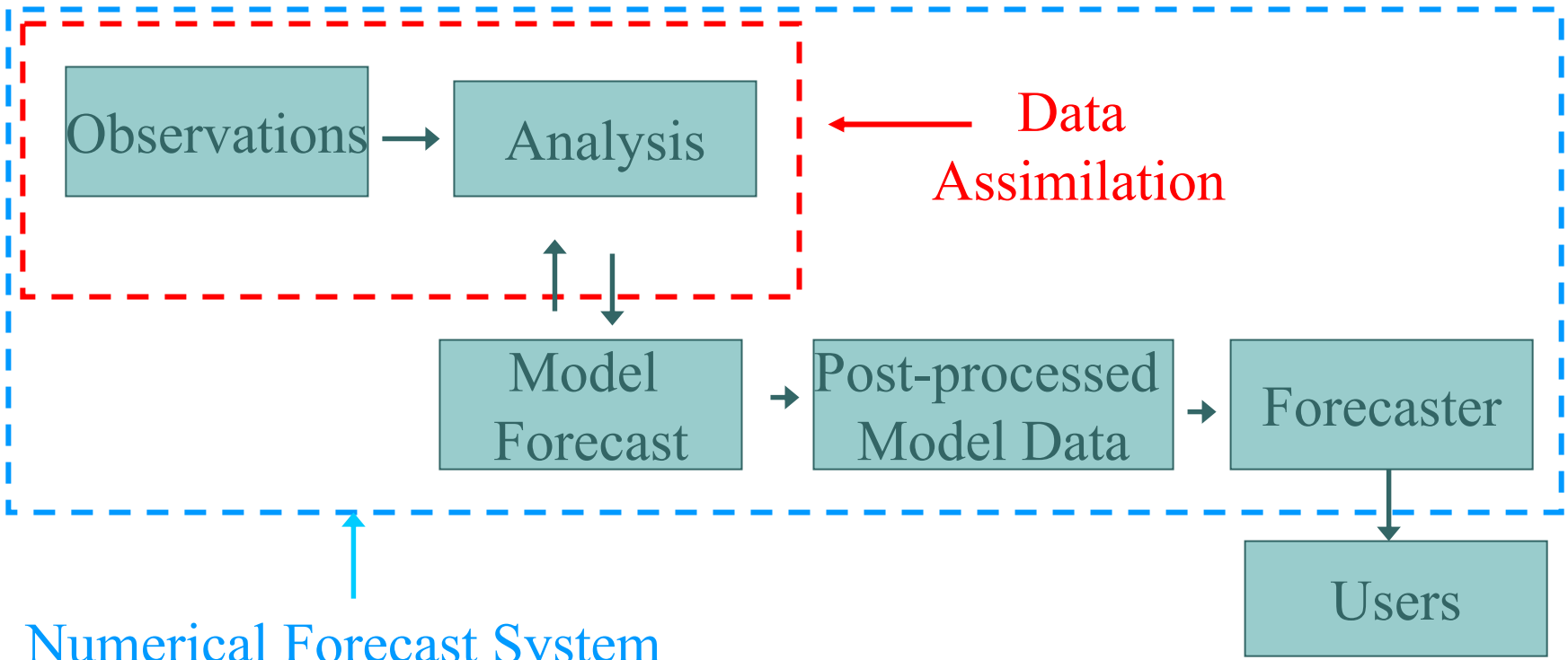
- Great deal of research on the economic benefits of weather research and forecasts

- Challenge with STAR was estimating benefits of a constituent element of weather forecasts

The Challenge

Impact of satellite data on forecasts can not be directly measured

- Satellite data assimilated into models used by forecasters
- Forecasts still rely greatly on subjective skill



How Much Satellite Data?

Satellite data used in operational data assimilation systems at the National Center for Environmental Prediction

- In addition to data from a range of other sources

- HIRS sounder radiances
- AMSU-A sounder radiances
- AMSU-B sounder radiances
- GOES sounder radiances
- GOES, Meteosat, GMS winds
- GOES precipitation rate
- SSM/I precipitation rates
- TRMM precipitation rates
- SSM/I ocean surface wind speeds
- ERS-2 ocean surface wind vectors
- Quikscat ocean surface wind vectors
- AVHRR SST
- AVHRR vegetation fraction
- AVHRR surface type
- Multi-satellite snow cover
- Multi-satellite sea ice
- SBUV/2 ozone profile and total ozone
- AIRS
- MODIS Winds
- Altimeter sea level observations (ocean data assimilation and wave data assimilation system)

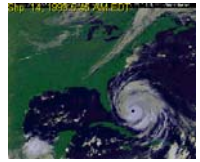
Impact of Data

- First step – need to isolate and identify the impact of satellite data
  - Such impact studies are relatively new
  - But impact studies are critical for assessing the incremental increases in the quality of (model) forecasts due to the addition of specific satellite data products

- Luckily, the Joint Center for Satellite Data Assimilation (JCSDA) had recently funded and/or completed a number of impact studies
  - However, impact studies completed not compiled in a single place nor user-friendly

- Once impact is determined, estimate the potential benefits that accrue from improved forecasts
  - CRITICAL ASSUMPTION – improvements in model forecasts results in improvements in operational forecasts

Economic Benefits - Examples



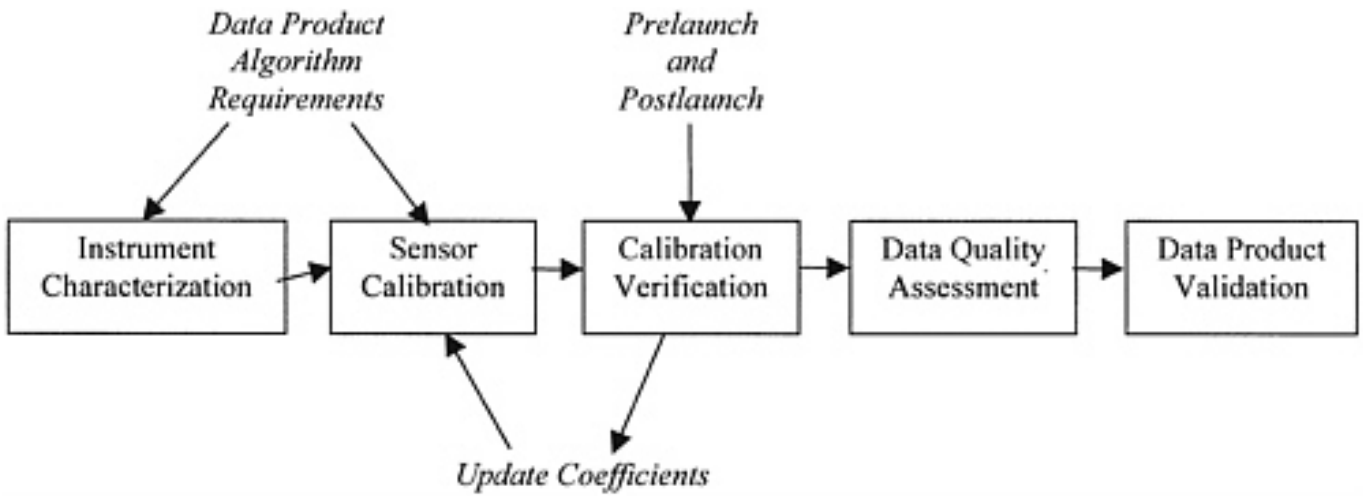
- Value of hurricane forecasts demonstrated previously (Willoughby, 2005; Considine et al, 2004)
  - For example, Considine argue that more accurate forecasts would result in fewer false alarms, preventing unnecessary evaluations and disruptions in production of gas and oil in the Gulf of Mexico – very conservative
  - Estimated that a 50 percent improvement in the 48 hour forecast would produce 15 million dollars of savings per season

- STAR demonstrated that the inclusion of GOES channel 4 (10.7μm) imagery and oceanic heat content inferred from altimetry observations improved hurricane intensity forecasts for the Atlantic by 3.5 percent in the 12 to 72 hour forecasts

- Assuming a linear relationship between the amount of improvement and the amount of savings, this means a savings of *more than 1 million dollars per season* due to GOES channel 4

Economic Benefits - Examples

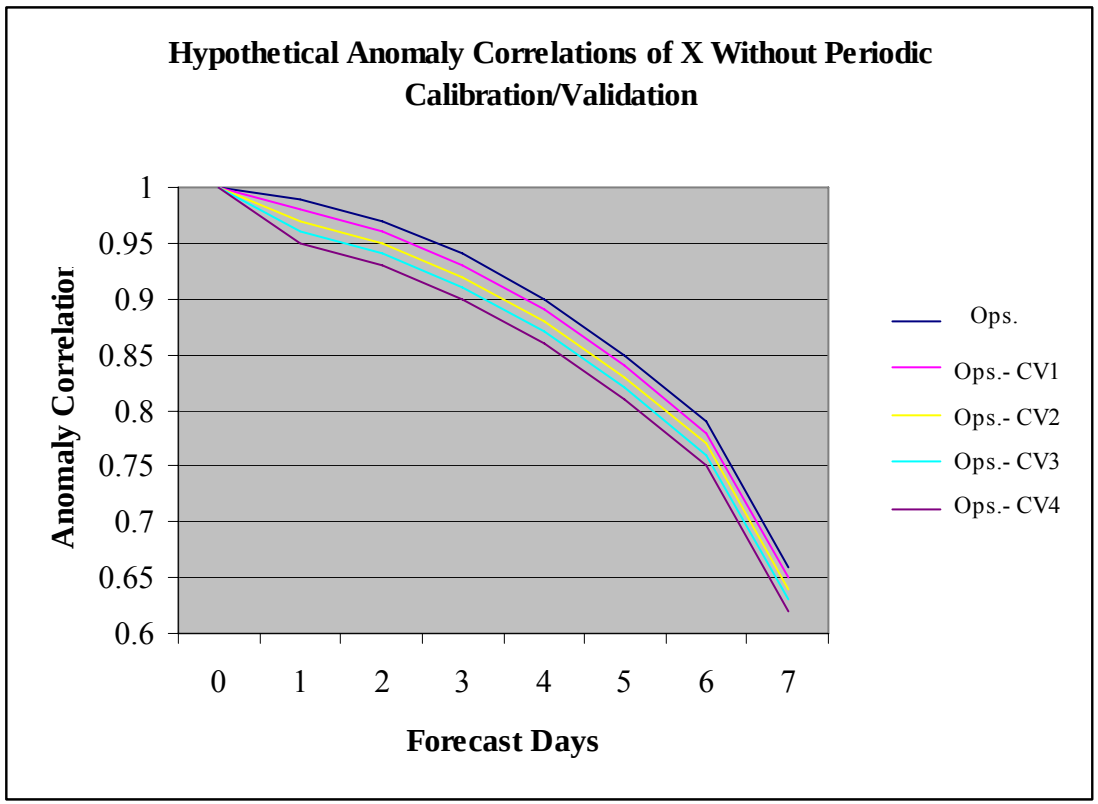
- Calibration and validation (cal/val) are integral activities of STAR in providing for accurate, precise radiances and accounting for instrument anomalies
- Operational mandate to provide ground-system calibration processing for all current and future NOAA series satellites
- Cal/Val focused on routine maintenance, not new products
- Interesting challenge to explore the estimation of economic benefits on work that is not focused (directly) on improving data
  - What is the impact?



Economic Benefits - Examples

- Hypothetical case study – documenting the degradation of data quality
  - What would happen if Cal/Val was not undertaken?
  - Negative impact on forecasts – negative economic benefits
- Analysis could be undertaken on any data product

The AC is the correlation between predicted and analyzed anomalies.



An AC of .6 is generally regarded as an indication of a "good" forecast.

Economic Benefits - Examples

- Any direct linkages to economic benefits?
  - Difficulty finding STAR products directly tied to specific users with potentially significant economic impact

- One possibility - Climate Data
  - STAR traditionally focused on data for operational forecasting, but increasingly being called on to help provide long-term climate observations.
  - Long-term climate data is provided after some level of quality control is performed on the existing observational record.
  - In the case of STAR's contribution, an important type of cleaning involves inter-satellite calibration to account for the errors and discontinuities across satellite systems over the years.

- Climate data can be utilized in climate forecasts, but we wanted direct linkages
  - Weather risk market as a possibility
  - Notional value of contracts in weather risk was over $8 billion in 2005
  - Data could be used to help price contracts (perhaps already is?)

Economic Benefits - Examples

- Table below provides a hypothetical example of the estimated cost to Alaskan wind farms if wind yields were lower than expected over a 30 day period.
  - STAR data would be critical in accurately forecasting wind yields
  - Faced with this forecast, Alaskan wind farms could purchase a wind contract to cover the estimated losses.
- While these figures are rather low, they represent only one geographic locale and one with a very limited number of wind installations
  - Also does not include such ancillary benefits as the displacement of fossil fuels and cleaner air and water.

Hypothetical Example of Sensitivity of Electricity Value to Wind Yields in Alaska

Capacity Utilization Due to Wind Yields	Total Power Capacity	Total Power Generated Over 30 Days	Wholesale Value of Power Generated ($70/MWh)
100%	1.6MW	1152MWh	$80,640
60%	.96MW	691.2MWh	$43,384

Concluding Remarks

- Based on our case studies, we identified one significant recommendation
  - As Pielke and Carbone (2002) discuss, the quantitative assessment of weather impacts is challenged by the fact that there is no standardized methodology or centralized collection of data.
  - Hence, the calculation of benefits and impacts can often have an arbitrary nature to it.

- Our primary recommendation - STAR should develop a consistent methodology and improved documentation of the impact of STAR's data products.

- Such a step would allow for a much more straightforward estimation of the economic benefits of STAR's data products.

- Currently moving forward on additional case studies to continue exploring how to adequately estimate economic benefits