Remote Sensing for Climate and Environmental Change

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Taking responsibility for developing and connecting these three elements in support of society’s needs represents a new social contract for the scientific community.

**Decadal Survey* Priorities**

- **Observations**
- **Analyses**
  - Forecasts
  - Models
- **Decision Processes**

Taking responsibility for developing and connecting these three elements in support of society’s needs represents a new social contract for the scientific community.

- generating scientific observations and conducting research
- transforming results into useful information
- distributing information to public and private sector managers, decision-makers, policy-makers, and the public at large

* Earth Science and Applications from Space: National Imperatives for the Next Decade and Beyond Committee on Earth Science and Applications from Space: A Community Assessment and Strategy for the Future
Role of Satellites in Global Change

Direct Observations

Altimetry
Sea Level Rise
1992-2009
(Nerem, 2009)

GRACE
Antarctic ice loss
2002-2009
(Velicogna, 2009)

InSAR
Antarctic ice loss
1996-2006
(Rignot, 2008)
Role of Satellites in Global Change

Minimizing Uncertainties in Models

- QuikScat Winds
- MLS Temp / water vapor
- AIRS (Temp/water Vapor)
- Jason (Sea Surface Height)
- CloudSat (cloud ice)
Model-Data Comparisons for IPCC Assessment

Estimates of Cloud Ice Concentrations from Models Used in the IPCC 4th Assessment

Actual Global Ice Concentrations Observed by CloudSat

Waliser (2009)
Aquarius will use an L-band radar (JPL) and radiometer (GSFC) to make monthly maps of sea surface salinity with precision of 0.2 PSU (.2 gkg$^{-1}$) and resolution of 150 x 150 km.

**Mean Salinity** from 12 CMIP3 Model Simulations of 20th Century Climate: POOR MODEL AGREEMENT

Partners: CONAE (INPE, ASI, CNES, CSA)  
LRD: 06/09/2011
SMAP will use a rotating 6-m deployable mesh antenna shared by an L-band radar (JPL) & radiometer (GSFC) to map soil moisture and freeze/thaw state with 10 km resolution every 3 days.

Li et al., (2007)

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The SMAP mission has not been formally approved by NASA. The decision to proceed with the mission will not occur until the completion of the National Environmental Policy Act (NEPA) process. Material in this document related to SMAP is for information purposes only.
History of Climate Model Intercomparison

1989 – Inception of DOE PCMDI (Program for Climate Model Diagnostics & Intercomparison)
1990-1995 - The Atmospheric Model Intercomparison Project (AMIP)
   30 Atmospheric GCMs perform a common experiment (prescribed SST & sea-ice), standardized output

1995-2000 –
   AMIP II – tighter experimental protocol, more extensive diagnostics
   The Coupled Model Intercomparison Project (CMIP)

AMIP & CMIP were highlighted in 2nd & 3rd IPCC Assessment Report (SAR-1995, TAR-2001)

2000 – 2003 - The Coupled Model Intercomparison Phase II - CMIP2
2003 – Present - The Coupled Model Intercomparison Phase III - CMIP3
   • About 75% of the more than 100 figures in IPCC AR4 Chapters 8-11 are based on CMIP3 results.
   • 4 of the 7 figures appearing in the IPCC “Summary for Policy Makers” are based on CMIP3

CMIP3 formed the model basis for the 4th IPCC Assessment Report (FAR-2007)

2009 – Present - The Coupled Model Intercomparison Phase V - CMIP5 (projected)

CMIP5 will form the model basis for the 5th IPCC Assessment Report (AR5-2013)
CMIP Resource, Research and Impacts

What made the difference in CMIP3/AR5?

An investment in infrastructure and standards
- Community-developed metadata convention “Climate-Forecast” (CF)
- Software to ensure model data compliance: The Climate Model Output Writer (CMOR)
- State-of-the-art data delivery methods The Earth System Grid (ESG)

Number of registered users: **2570**
Dataset Size: **36 Terabytes** in 83,000 files
Amount downloaded: **536 Terabytes** in 1,781,000 files

As of 2007

~500 Total as of 2010
**IPCC AR5 - New Emphases, Opportunities, & Needs:**

Model “Scoring” Based on Measures of Model Quality

**CMIP3 GCM Performance**

New WGCM & WGEN Metrics Subpanel: Use observation-based “metrics” to assess model representations of past climate -> use to weight models’ climate projections

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Gleckler, P. et al. (2008)
Carbon/GHG focus

- Grassroots effort started in 2008 by JPL and partners at DOE labs, NOAA, & NASA for climate policy/treaty support
- Since expanded to engage over 30 US agencies, universities, NGOs, and international partners
- Scoping study underway for an integrated global monitoring system (surface & space)

Greenhouse Gas Information System (GHGIS)

NASA Carbon Monitoring System (CMS)
- New congressional mandate for policy support
- NASA’s response
  - 2 Pilot Projects (global & US)
  - Scoping Study for future system
- Actively exploring additional pilot projects
Information Systems Flow

- Are FF emissions from individual point sources exceeding reported values?
- How are individual FF point sources being operated (dynamic behavior)?
- Are Country-A’s total GHG emissions exceeding their reported values?
- Are area-source (AFOLU) emission estimates for a given region accurate?
- If policy X isn’t meeting its ultimate objective, what needs adjustment? Where?
- Is Project-Y’s claimed baseline for a forest carbon offset credit real?
- Are disturbances occurring that impact Country-B’s claimed carbon credits (is the offset permanent)?

And how good is good enough (re: uncertainty)?

- Urban & Large Point Source Monitoring
- Global GHG Flux Monitoring
- Global Carbon Stock Monitoring
Imaging spectroscopy used by NASA, USGS, and NOAA to estimate thickness and volume of surface oil.

Spectroscopic Basis: Infrared C-H Bond Absorptions

AVIRIS Gulf Measurements

NASA AVIRIS Spectra from the Gulf

Surface Fraction

Thickness

Quantitative Volume Estimates

AVIRIS Gulf Measurements

Aerial Fraction

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Advanced Rapid Imaging Analysis

“Nature creates hazards, but the actions or inactions of people, societies and governments create disasters”

Objective
Build an end-to-end prototype system enabling near-real-time earthquake science, assessment, response, and recovery.

Automate data processing. Reduce latency from weeks to days (InSAR) and days to minutes (GPS).
Integrate InSAR, GPS, seismology, modeling.
Deliver actionable science products.

2010 M8.8 Chile Earthquake Coseismic Interferogram
2007 Peru Earthquake Coseismic Data, Fault Slip and Tsunami Source Model
2003 Iran Earthquake Decorrelation Map for Rapid Damage Assessment
Figure shows horizontal displacements based on ARIA version 0.3 position estimates for GEONET stations. Coseismic displacement is shown in red, and first 8 hours of postseismic motion is shown in blue, including motion caused by aftershocks. Bars at end of vector show 95% error estimate. Solutions courtesy of ARIA team at JPL and Caltech (email aria@jpl.nasa.gov or aria@caltech.edu). All original GEONET RINEX data provided to Caltech by the Geospatial Information Authority (GSI) of Japan.
Summary

• Remote sensing is being used more and more for decision-making and policy development.

• Specific examples are:
  – Providing constraints on climate models used in IPCC assessments
  – Framing discussions about greenhouse gas monitoring
  – Providing support for hazard assessment and recovery.