Opportunities

• Recent momentum gained from consensus reports, improved public awareness of climate change

• Improved Earth Science budgets
Emerging Priorities

• Common themes have emerged as priorities
  • Societal benefits, informing policy decisions & management choices
  • The human element of the climate system
  • The need to provide for both new observations & long-term sustained observations
Challenges
Satellite Measurements: Spatial Coverage

- Satellite measurements:
  - Provide global context to augment existing ground and airborne observations
  - Provide coverage of regions not readily accessible or instrumented by other means

AIRS July 2003 CO2 (ppm)

AIRS JULY 2008 CO2 (ppm)
Satellite Measurements: Spatial Resolution
Satellite Measurements: High Precision

- Identifying sources and sinks of atmospheric carbon dioxide from atmospheric measurements is challenging
  - Requires surface sensitivity and high precision

Plumes from medium-sized power plants (4 MtC/yr) elevate $X_{\text{CO}_2}$ levels by ~0.5% (2ppm) for 10’s of km downwind [Yang and Fung, 2010].

Variations of CO$_2$ are rarely larger than 1-2% on 100 – 1000 km scales

Kawa et al., 2008
The OCO and GOSAT missions were designed to provide complementary information on global CO$_2$ sources and sinks

- GOSAT provides greater spatial coverage and a 3-day repeat cycle to resolve weather (emphasis on carbon sources)
- OCO provides greater spatial resolution and higher precision to investigate carbon sinks
Validating Remote Sensing CO$_2$ Measurements: TCCON

- The OCO and GOSAT mission rely on the Total Carbon Column Observing Network, TCCON, as a critical component of their validation strategy
  - High resolution Fourier transform spectrometers measure CO$_2$ and O$_2$ absorption in same spectral regions as OCO
  - TCCON results validated with over-flights by aircraft carrying *in situ* instruments calibrated against WMO CO$_2$ standard.
  - Simultaneous TCCON FTS and space based measurements are compared to transfer the WMO standard to the spacecraft measurements.
The Launch of GOSAT and Loss of OCO

GOSAT launched successfully on 23 January 2009

OCO was lost a month later when its launch system failed
Since then...

• NASA’s Earth Science Directorate instructed the OCO science team to document the justification and requirements for an OCO reflight.

• December 2009: The U.S. Congress added funding to the NASA FY2010 budget to restart the OCO Mission

• February 2010: The President’s 2011 NASA budget proposal included funding for a “Carbon Copy” of the OCO mission, now designated “OCO-2,” with a launch date “no later than February 2013”

• The OCO-2 mission is currently in development. Mission Implementation Phase began on October 1, 2010
Looking ahead

• June 2010: NASA released its Climate-Centric Architecture for Earth Science
  – Includes provision for assembly of an OCO-3 instrument from OCO-2 spares, making a follow-on instrument available for a flight of opportunity as early as 2015
  – Accelerates the decadal survey-recommended ASCENDS mission, which would leverage active CO$_2$ measurements to provide day/night measurements for all seasons and latitudes, baselined to launch in 2019-2020

Pre-decisional – for Planning and Discussion Purposes Only
Future Observations: Challenge

• Balancing need for new measurements with need for providing sustained observations
  – For example, increasing spatial coverage vs. adding channels vs. “continuity”

• Need to understand the value of these new/sustained measurements in the context of our overall system of measurements and models to set priorities
“...The U.S. research community has excelled at developing and testing innovative observational and experimental methods but has had more limited success transforming those observations and experiments that prove successful into sustained, long-term networks and facilities. The focus on innovation must be maintained and our ability to expand long-term observations and to maintain proven, essential data sources must be strengthened.” – Draft CCS Plan, page 12
Conclusions

• Space-based remote sensing instruments hold substantial promise for advancing carbon cycle science

• The principal advantages of these systems include
  – Spatial coverage (ocean and land, near pole-to-pole)
  – Sampling density (needed to resolve CO₂ weather, point sources)

• Integration with ground and airborne networks is essential to validating, interpreting, and maximizing the benefit of remote sensing observations

• Need a long-term vision to establish and address community priorities
  – Needs to incorporate ground, air, and space-based assets
  – Needs to balance calls for new observations and continued measurement records
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- OCO-3 Concept Study Team