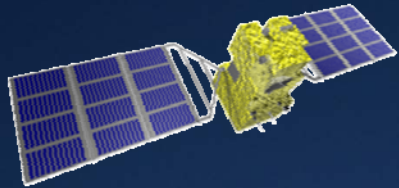




CEOS Atmospheric Composition Constellation Meeting (ACC-11)



Ongoing NASA/JAXA/NIES co-operation

David Crisp, OCO-2 Science Team Leader
Jet Propulsion Laboratory, California Institute of Technology

April 2015



Exploiting the Benefits of Multiple Missions

- **Space-based remote sensing observations hold substantial promise for future monitoring of CO₂ and other greenhouse gases**
 - These measurements will complement existing ground-based data with increased spatial coverage and sampling density
- **Within the next decade, a series of missions with a range of CO₂ & CH₄ measurement capabilities will be deployed in low Earth orbit**
 - GOSAT, OCO-2, TanSat, GOSAT-2, OCO-3, MERLIN, ...
- **Much greater benefits could be realized if these missions could be coordinated, and their products can be cross-calibrated and cross validated so that they can be combined to yield a self-consistent, continuous climate data record**
- **The NASA, JAXA, and NIES, teams on the GOSAT/OCO-2 teams have been pioneers in the implementation of this approach.**



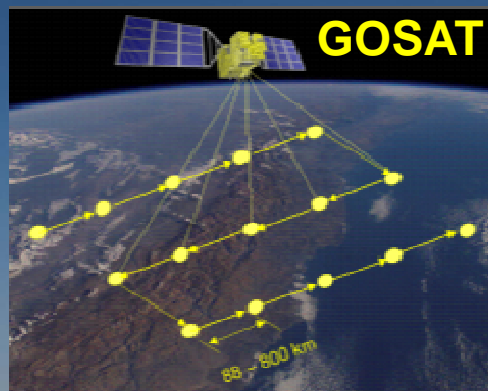


The OCO / GOSAT Collaboration

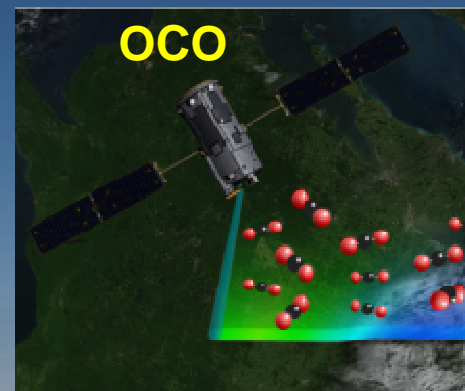
- The original objectives of this partnership were to:
 - Accelerate understanding of this new data source
 - Facilitate combining GOSAT and OCO results in flux inversion models
- The approach included two major components:
 - Cross calibrate OCO and GOSAT instrument radiometric standards
 - Cross validate OCO and GOSAT X_{CO_2} retrievals against a common standard: the Total Carbon Column Observing Network (TCCON)



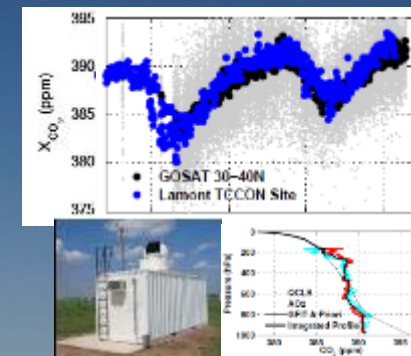
Cross calibration of radiometric standards prior to launch.



Uniform sampling with 3-day repeat cycle



Continuous high resolution measurements along track



Validation against TCCON observations





The Pioneers: GOSAT and OCO

Space based measurements provide new tools for measuring CO₂



GOSAT launched successfully on 23 January 2009



OCO was lost a month later when its launch system failed





The ACOS/GOSAT Collaboration



Vicarious Calibration



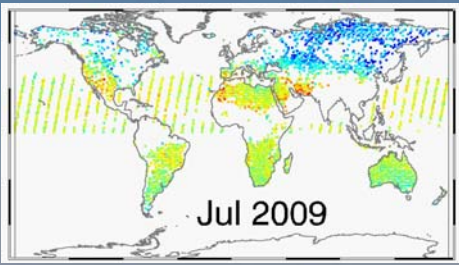
Retrieval Algorithm

Forward Radiative Transfer Model
Spectra + Jacobians

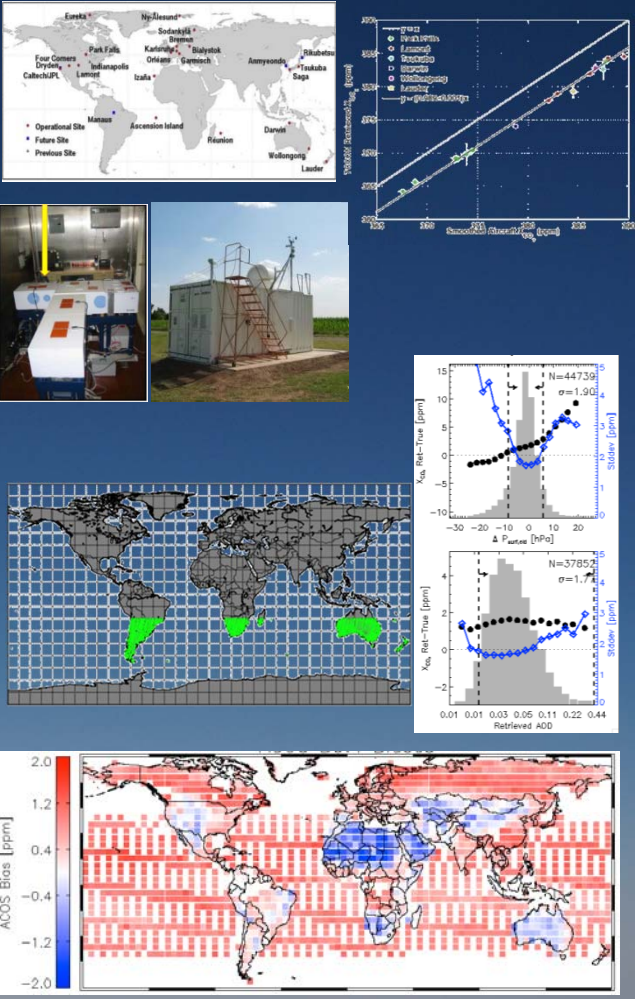
Instrument Model
Spectral+Polarization

Inverse Model

- Compare obs. & simulated spectra
- Update State Vector



Validation & Screening



not converged
 ?
 converged





Elements of a Calibration-Validation Strategy

Pre Launch:

- **Cross calibration of pre-launch radiometric standards**
- **Exchange of gas absorption coefficient and solar databases**
- **Retrieval algorithm development/intercomparison**
- **Validation system development (TCCON + Tsukuba FTS?)**
- **Dual/multi-Satellite OSSE's – what do you gain with truly coordinated observations**

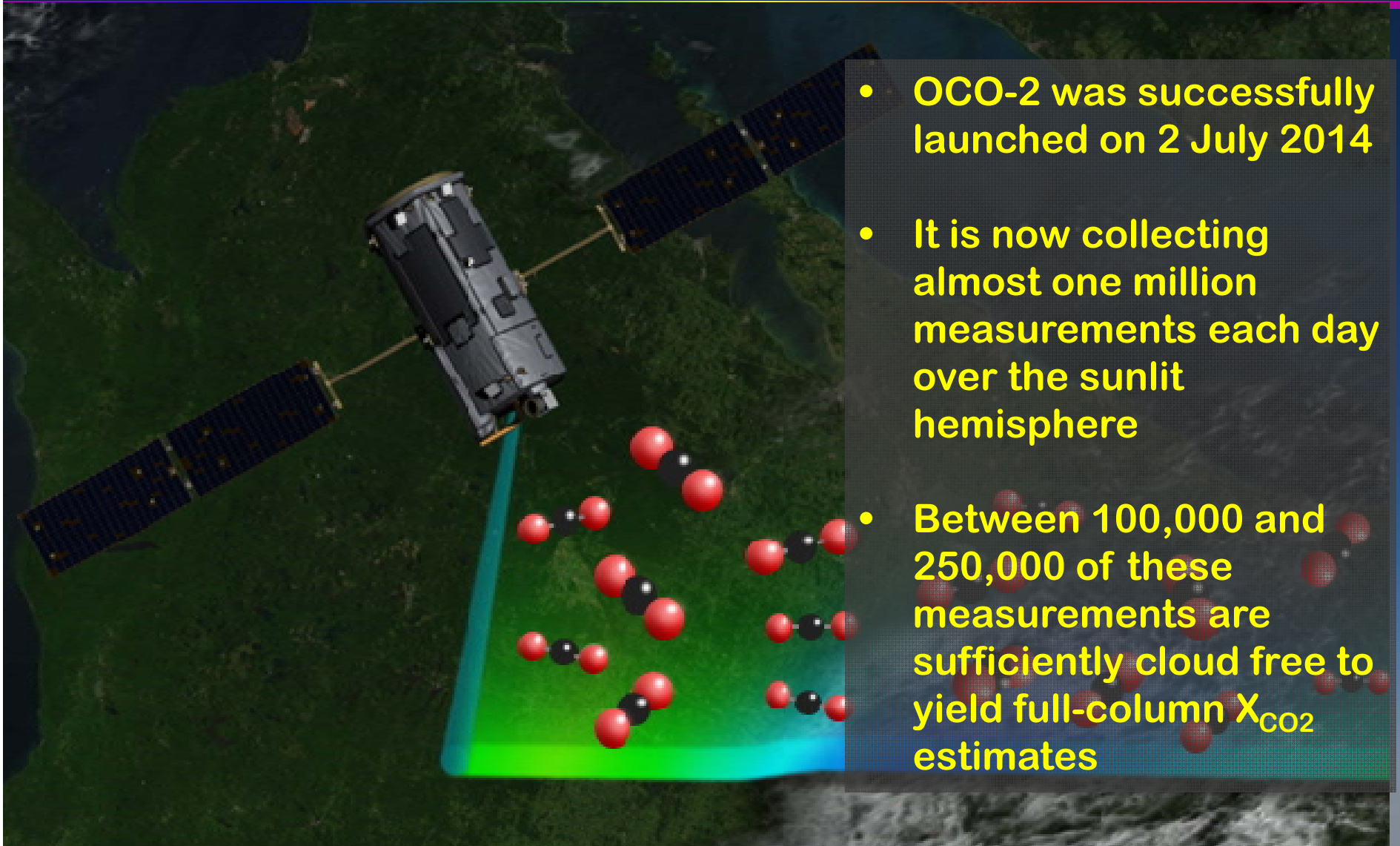
Post Launch:

- **Cross calibration of solar/lunar/Earth(vicarious: RRV+?) observations**
 - Including exchange of solar and lunar (ROLO) standards
- **Cross validation: TCCON, validation campaigns**
- **Continued retrieval algorithm development/intercomparison**
- **Intercomparisons of flux inversions**





The Next Step - The NASA Orbiting Carbon Observatory-2 (OCO-2) Mission



- OCO-2 was successfully launched on 2 July 2014
- It is now collecting almost one million measurements each day over the sunlit hemisphere
- Between 100,000 and 250,000 of these measurements are sufficiently cloud free to yield full-column X_{CO_2} estimates





NASA/JAXA/NIES/MoE MOU for GOSAT, OCO-2, and GOSAT-2

- In March 2015, NASA and the GOSAT/GOSAT-2 partners (JAXA, NIES, MoE) signed a new Memorandum of Understanding (MOU) for the GOSAT, OCO-2, and GOSAT-2 missions.
 - Pre-launch cross calibration
 - On-orbit calibration
 - Conduct annual technical interface meetings
 - Implement a common validation approach
 - Establish a joint mission science team



GOSAT



OCO-2

GOSAT-2





Summary

- The strong, continuing collaboration between the GOSAT and OCO-2 teams has dramatically accelerated our ability to collect, analyze and use space based measurements of CO₂ for studies of the carbon cycle.
- The GOSAT/OCO-2 collaboration provides a model for future space based greenhouse gas monitoring efforts.
- The extension of this collaboration to the GOSAT-2 and OCO-3 missions provides opportunities to extend this valuable climate data record beyond the lifetimes of GOSAT and OCO-2 missions.
- This closely coordinated *ad hoc* constellation of greenhouse gas satellites also paves the way for future space-based greenhouse monitoring systems.

