NASA Earth Science Activities and Plans

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With inputs from multiple colleagues at NASA HQ and Field Centers!

ESD's Interagency Coordination Efforts

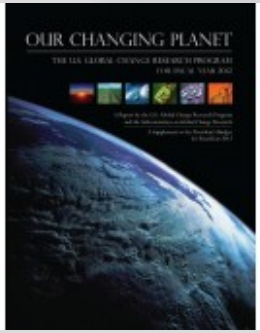
National Science And Technology Council (NTSC)

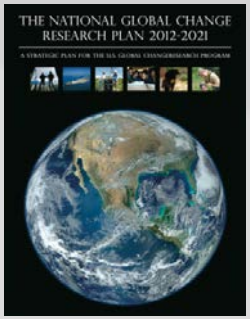
Committee on Environment, Natural Resources and Sustainability (CENRS)

Subcommittee on Global Change Research (SGCR)

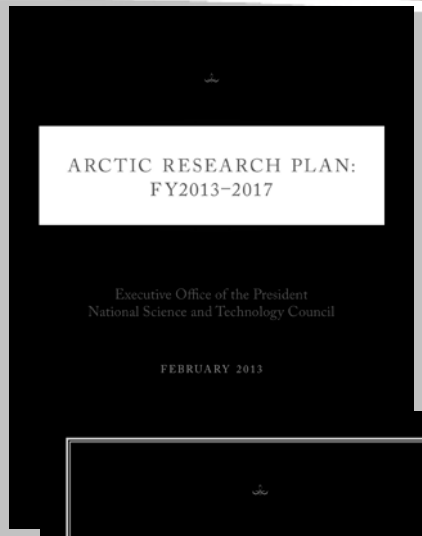
U.S. Global Change Research Program (USGCRP)

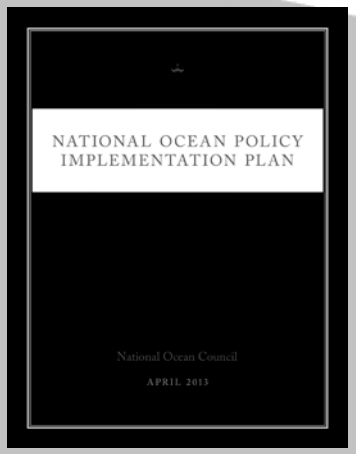
CENRS Sub-Committees, WGs, & Task Forces
Air Quality Research (AQRS)
Critical and Strategic Mineral Supply Chains (CSMSC)
Interagency Arctic Research Policy Committee Interagency Working Group (IARPC)
Integration of Science and Technology for Sustainability Task Force
National Earth Observations Task Force (NEO)
Disaster Reduction (SDR)
Ecological Services (SES)
Global Change Research (SGCR)
Ocean Science & Technology (SOST)
Water Availability & Quality (SWAQ)
Toxics & Risks (T&R)
US Group on Earth Observations (USGEO)

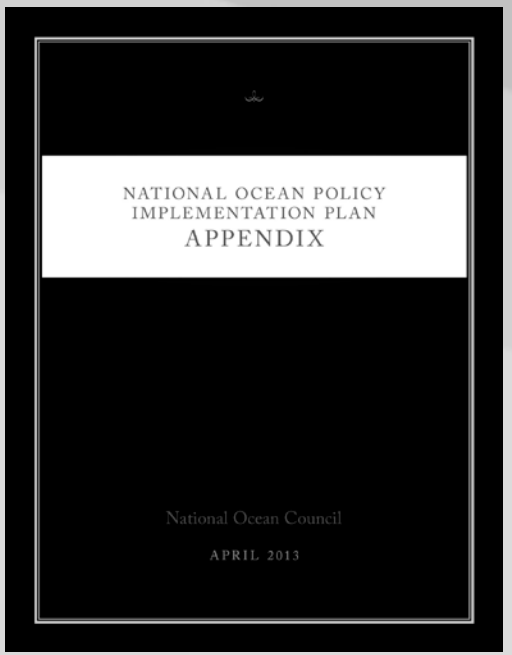


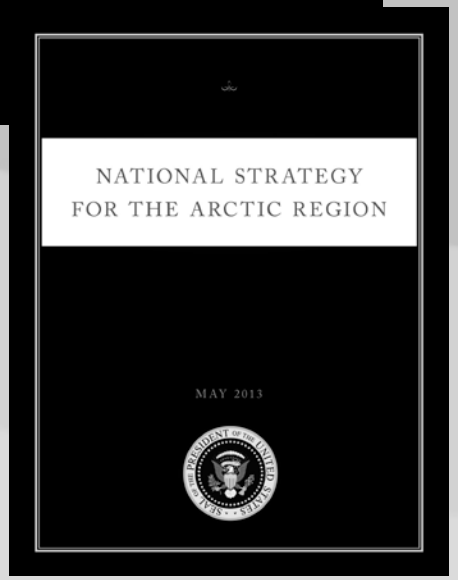


Recent Interagency Plans …









NASA Earth Science Operating Missions 2014

GPM Launched 2/27/14!

GPM launching from Tanegashima, Japen – 2/28/14

GPM climbing to its altitude just over 400 km

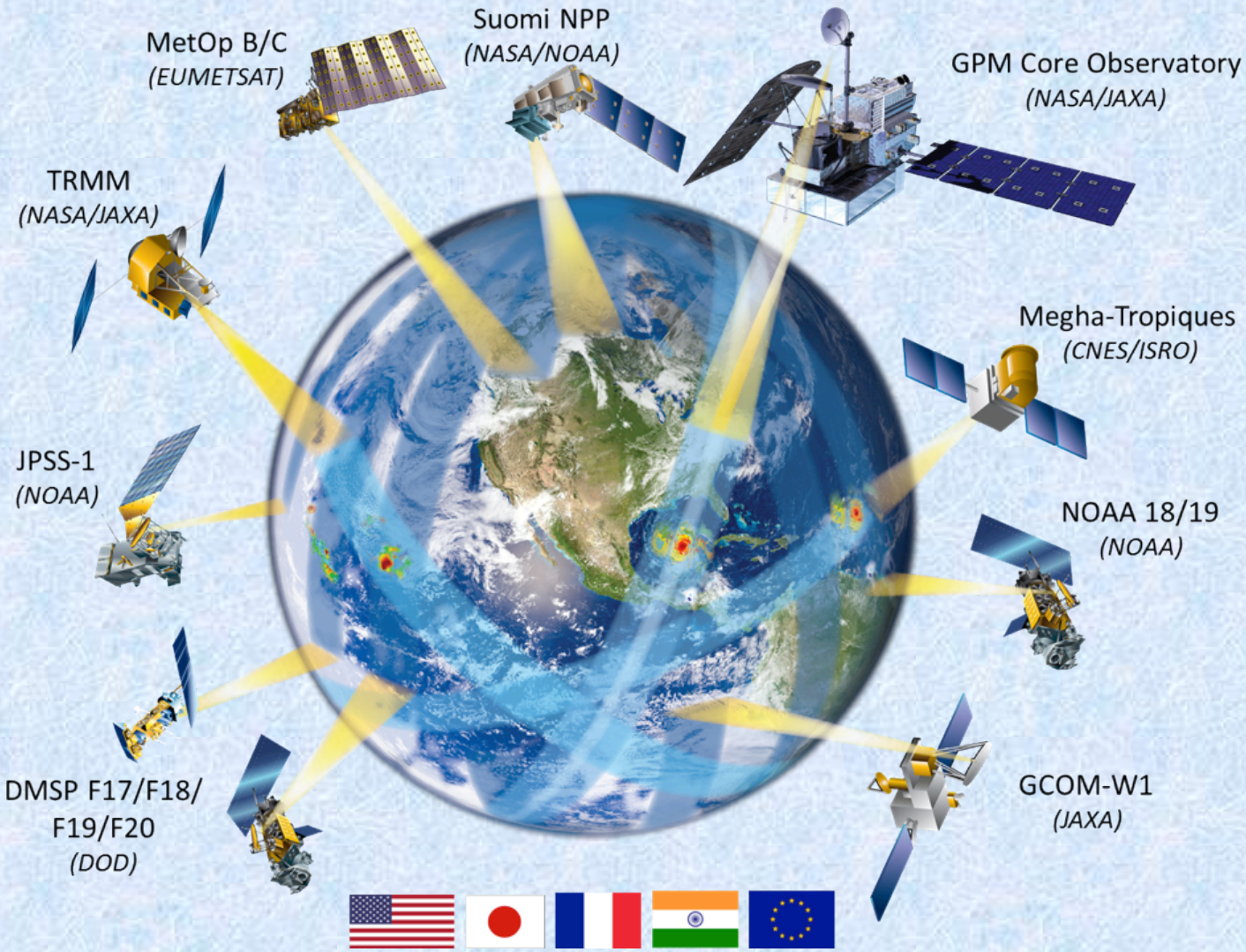
US Ambassador Caroline Kennedy speaking after launch

GPM Program Scientist Ramesh Kakar speaking in Japan

NASA TV Coverage of GPM launch with Daliia Kirschbaum (left) and Aries Keck (right)

"Launch party" for GPM at NASA Goddard Visitors' Center

GPM's Global Scope



The GPM Core Observatory serves as an anchor to ensure that all constellation satellites produce uniform next-generation precipitation estimates everywhere in the world every three hours.

GPM International Science Collaboration

NASA has 22 active science and ground validation research projects with investigators from 19 countries to support satellite algorithm improvement and data evaluation including:

Joint Warm season orographic rain field campaign in North Carolina with NOAA (May-June 2014)

Joint Cold season snowfall field campaign with Environment Canada (Jan-Feb 2012)

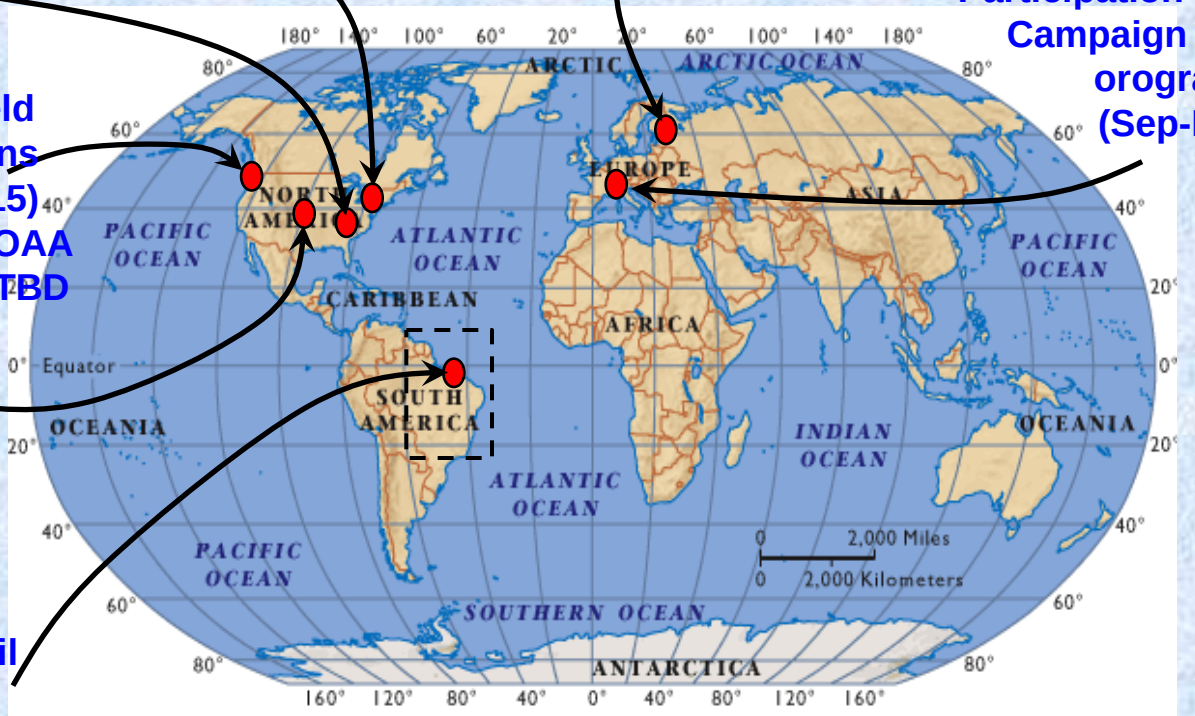
Joint campaign with Finland and NASA's CloudSat mission on light rain in Helsinki (Sep-Oct 2010)

Participation in EU-Led Campaign targeting orographic rain (Sep-Nov 2012)

Cold season rain/snow field campaign, ocean/mountains Washington (Nov-Dec. 2015) Environment Canada and NOAA participation, other agency TBD

Joint campaign with U.S. Department of Energy on convective rain over land in Oklahoma, USA (Apr-Jun 2011)

Joint campaign with Brazil targeting warm rain in Alcântara, Brazil (Mar 2010) Participation in other rain campaigns (2012-2014)

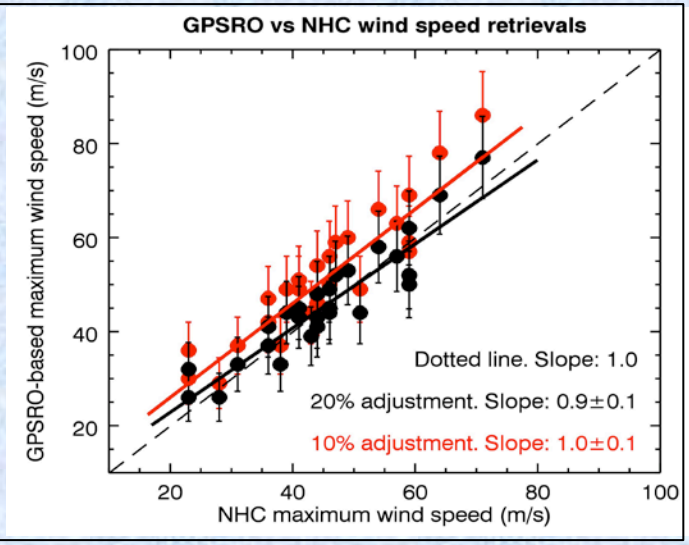


Hurricane intensity estimation: The GPS perspective

GPS-based vs National Hurricane Center intensity

First estimates of hurricane intensities (maximum wind speed) from GPS radio occultations (GPSRO) and the *Wong and Emanuel* [2007] hurricane model.

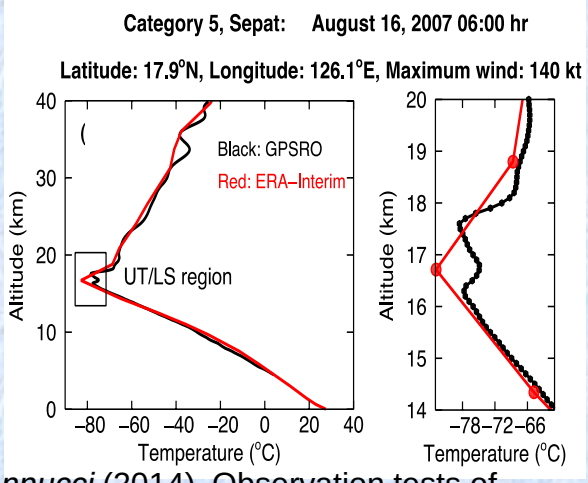
GPSRO-derived hurricane intensities show 0.9 linear correlation with respect to NHC intensities with a small bias. GPSRO shows great potential in augmenting current hurricane datasets, with possible applications to the initial vortex parameterization and intensity forecasting.

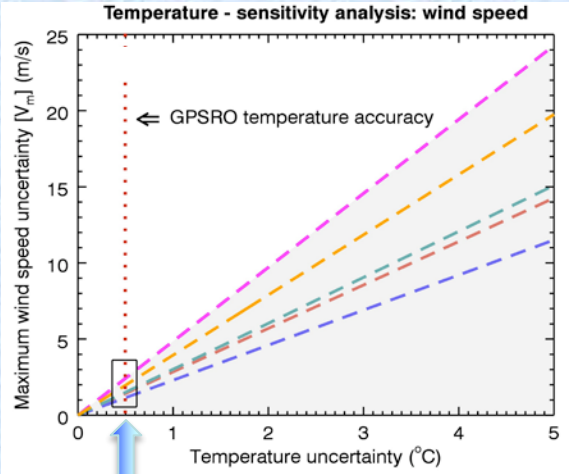


Accuracy of the GPSRO-retrieved hurricane intensities: Temperature sensitivity

Precise measurements of the eyewall temperature is the key to hurricane intensity estimation – **GPSRO observations penetrate clouds and heavy precipitation.**

Eyewall temperature at the tropopause height is a sensitive indicator of hurricane intensity. **GPSRO temperature accuracy is ~0.5 – 1.0 K (black rectangle). This translates to a 1–4 m/s hurricane intensity error.**





GPS temperature accuracy is ~0.5–1.0 K, suggesting that GPS can introduce only a 1– 4 m/s hurricane intensity error.

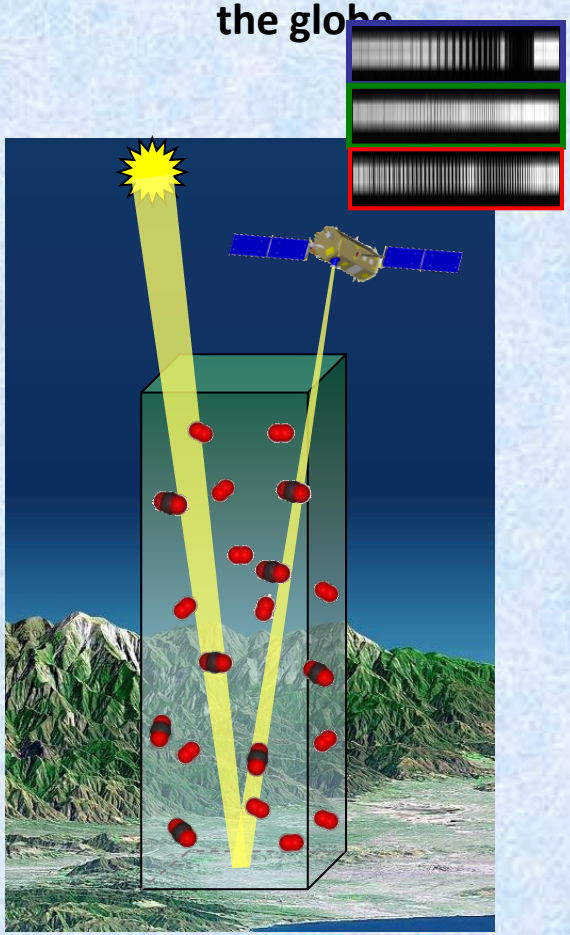
Vergados P., *Z. Luo, K. Emanuel, and A. J. Mannucci* (2014), Observation tests of hurricane intensity estimations using GPS radio occultations, *J. Geophys. Res. – Atmospheres.*, 13 p., doi:10.1002/2013JD020934

Selections from Satellite Calibration Interconsistency Studies ROSES Element

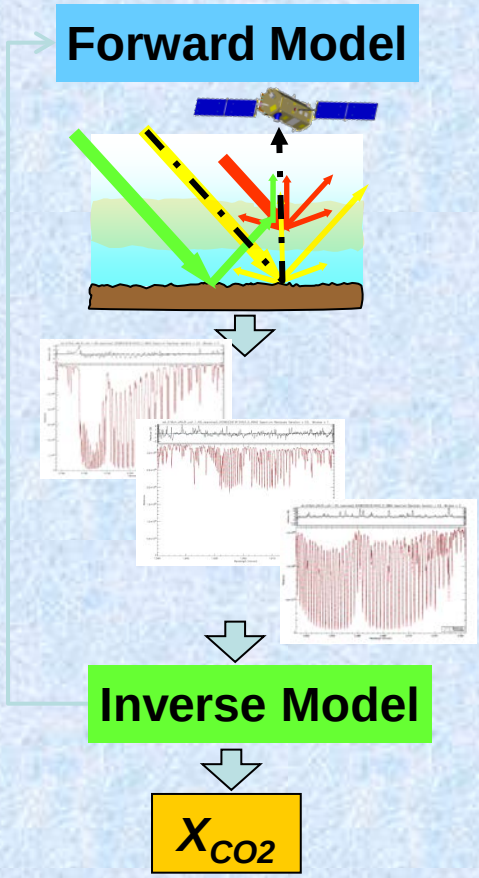
- Hartmut Aumann - JPL – Using Cloudy Radiances as a New Test for the Inter-Calibration of AIRS and IASI
- Emmanuel Dinnant – Chapman Univ. – Inter-Calibration of Aquarius and SMOS
- Helen Fricker – SIO – Long-Term Calibration of Satellite Altimeter Range Measurements from GPS Reference Surveys of the Salar de Uyuni, Bolivia
- Simon Hook – JPL – Cross Calibration and Interconsistency of Mid and Thermal Infrared At-Sensor Products for Earth Science
- Brian Kahn – JPL – Aqua-AIRS and NOAA-HIRS Pixel- to Global-Scale Radiance Comparisons for Improved Long-Term Cloud-Type Trends
- Carl Mears – RSS – Improved and Extended Temperature Measurements from Microwave Sounders
- Patrick Minnis – LaRC – Intercalibration of Satellite Imaging Channels to Facilitate Consistent Retrieval of Atmospheric and Surface Climate Data Records
- Brian Soden – U. Miami – Calibration and Interconsistency of Satellite Upper Tropospheric Water Vapor Radiances
- Lawrence Strow – UMBC – Hyperspectral Infrared Earth Radiance Time Series
- David Tobin – U. Wisconsin – Hyperspectral Infrared Satellite Intercalibration Studies
- Omar Torres – GSFC – A Multi-Satellite Approach to Obtain a Continuous Record of Aerosol Optical Depth Using Past and Present Satellite Observations in the UV

OCO-2 Measurement Approach

- **Collect spectra of CO_2 and O_2 absorption in reflected sunlight over the globe**



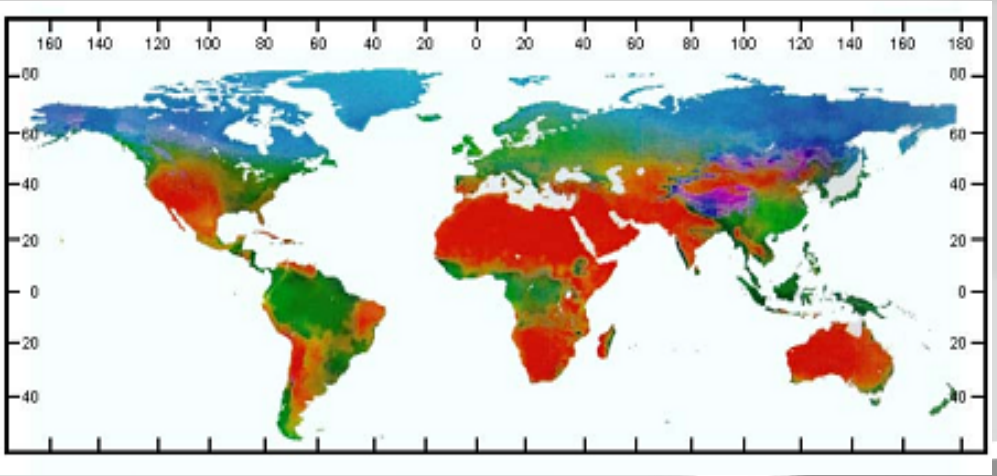
- **Retrieve** variations in the *column averaged CO_2 mixing ratio* over The sunlit hemisphere



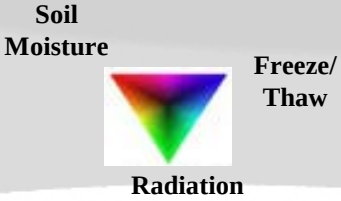
- **Validate measurements to ensure CO_2 accuracy of 1 - 2 ppm (0.3 - 0.5%)**

SMAP Science Objectives

- SMAP science objectives are to provide global mapping of soil moisture and freeze/thaw state (hydrosphere state) enabling science and applications users to:
  - Understand processes that link the terrestrial water, energy & carbon cycles
  - Estimate global water and energy fluxes at the land surface
  - Quantify net carbon flux in boreal landscapes
  - Enhance weather and climate forecast skill
  - Develop improved flood prediction and drought monitoring capability



Primary Controls on Land Evaporation and Biosphere Primary Productivity



Earth Science Missions & Applications

Early Adopters: *New with SMAP*

Purpose is to conduct pre-launch applications research to accelerate use of data after launch.

Organizations with clearly-defined needs for *SMAP*-like data products evaluate & demonstrate the utility of *SMAP* data for their application and decision making.

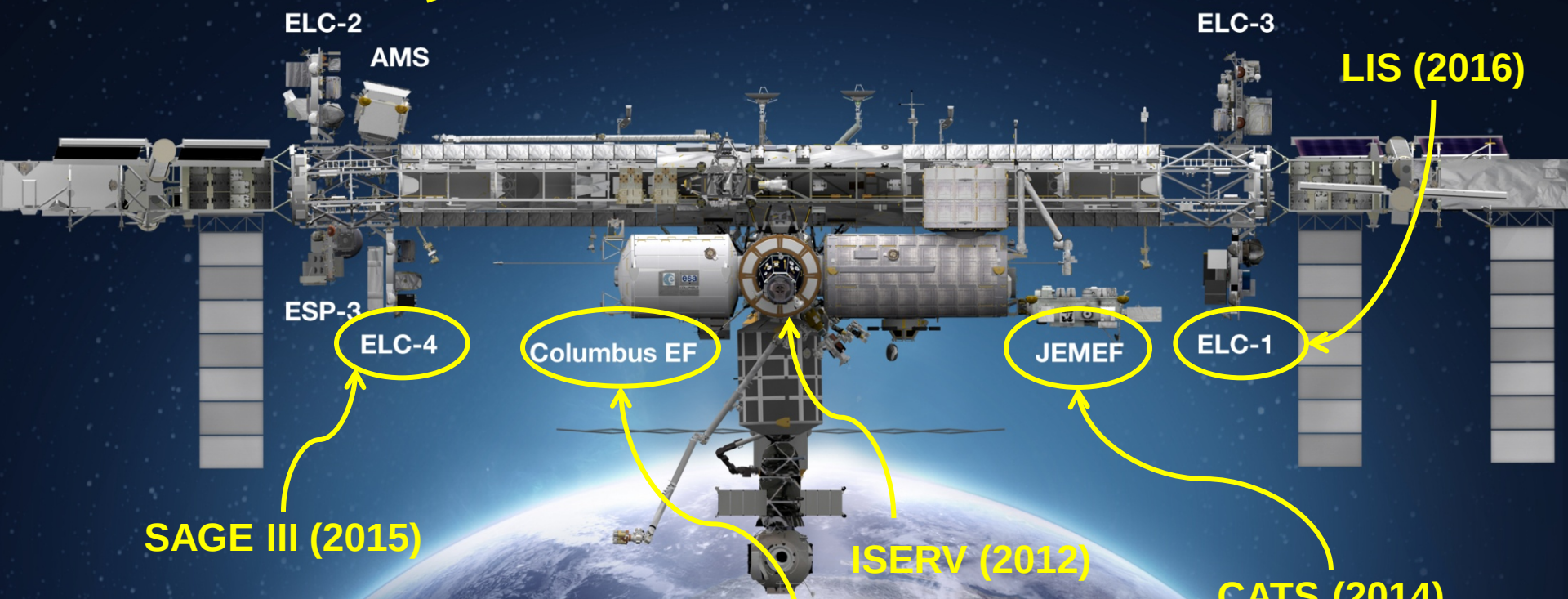
Early Adopters:

- » Use data products prior to launch (simulated data and cal/val data from field campaigns)
- » Provide feedback on products and formats to increase applications value of mission
- » Streamline and accelerate use of data soon after launch and check-out
- » Supply own resources to do these activities

25+ organizations are currently EAs from public & private-sector, domestic & foreign

International Space Station

Earth Science Instruments



LIS (2016)

SAGE III (2015)

ISERV (2012)

CATS (2014)
HICO (2009)

RapidSCAT (2014)

External Logistics Carriers – ELC-1, ELC-2, ELC-3
External Stowage Platforms – ESP-3
Alpha Magnetic Spectrometer
Columbus External Payload Facility
Kibo External Payload Facility

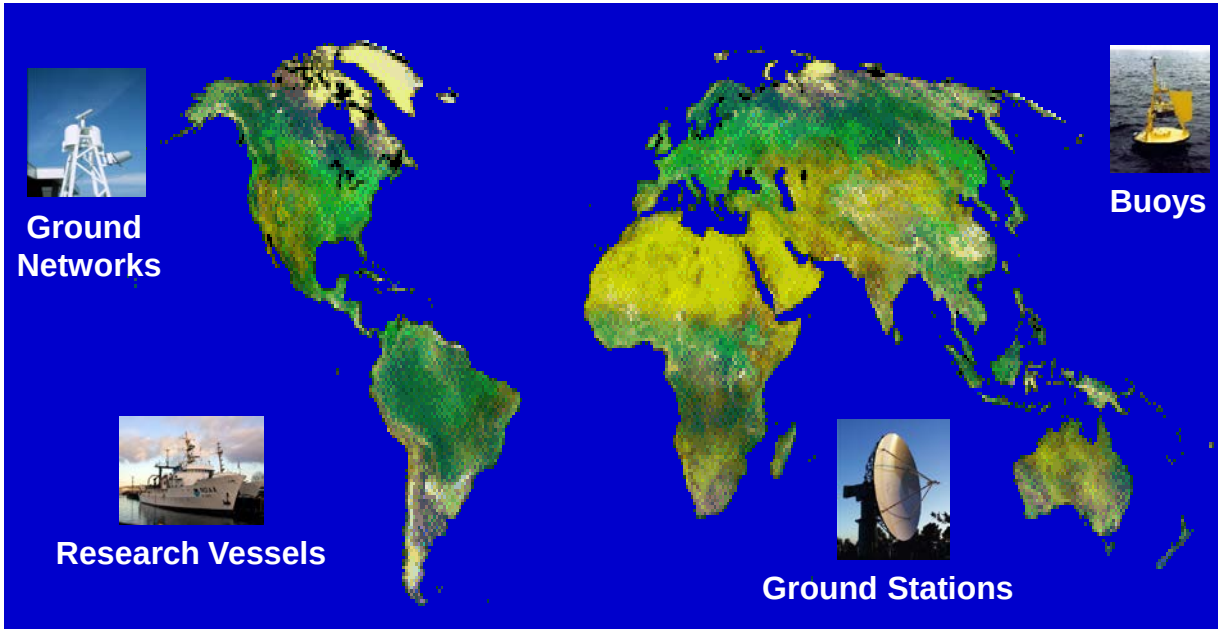
End-to-end Support in a Globally Integrated Program

Airborne Sensors

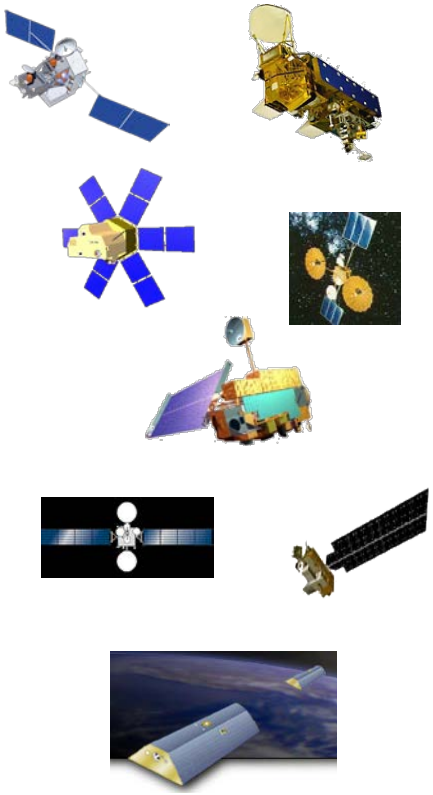
Research Balloons

Uninhabited Aerial Vehicles

Field Campaigns



Space-based: Sensors & Data Relay



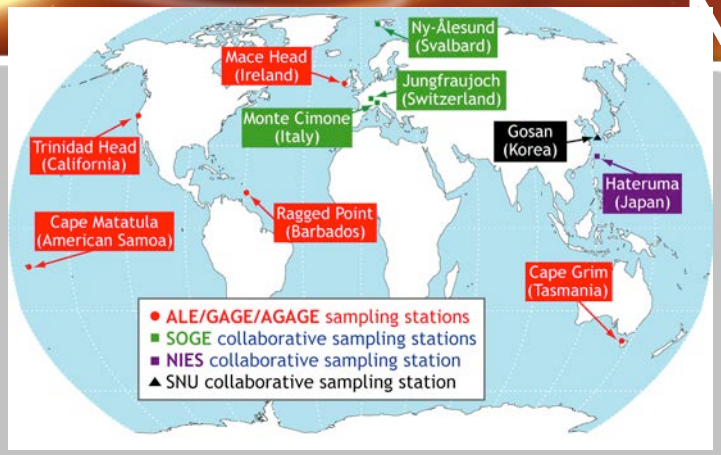
Ground Stations

Research Balloons

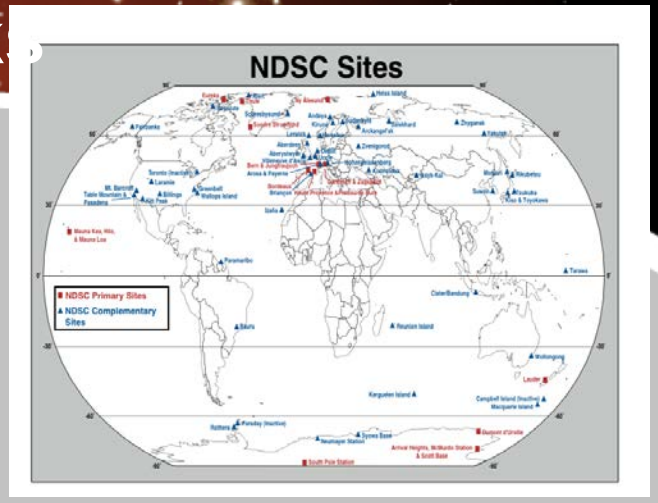
NASA's & Partners' ground, sea, air and in-situ measurements augment space-based observations to validate science results and provide complimentary measurements

Examples of NASA-Supported Ground Networks

AGAGE

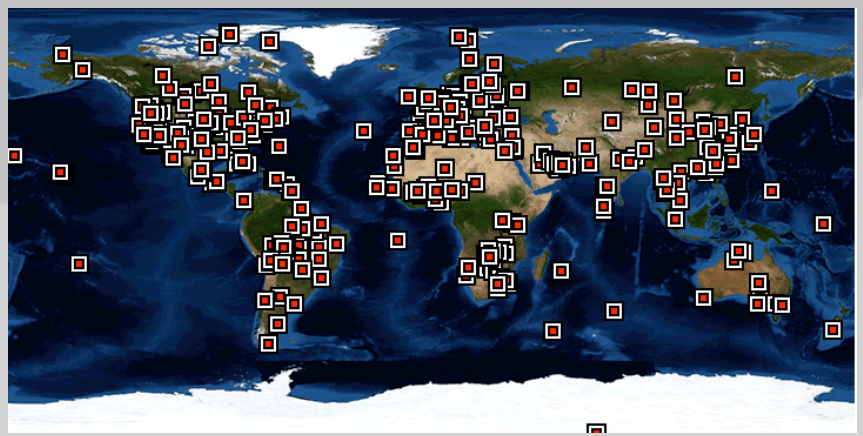


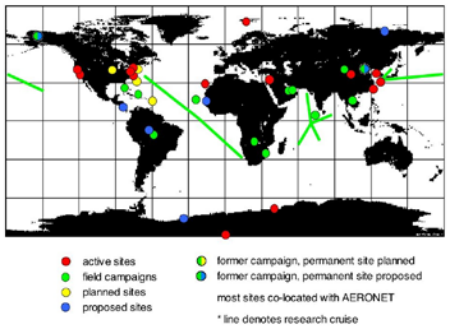
NDACC



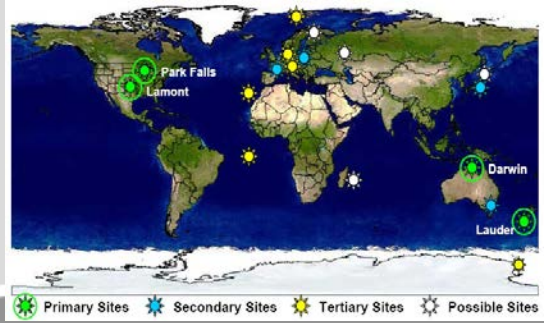
ILRS

AERONET





MPLNet

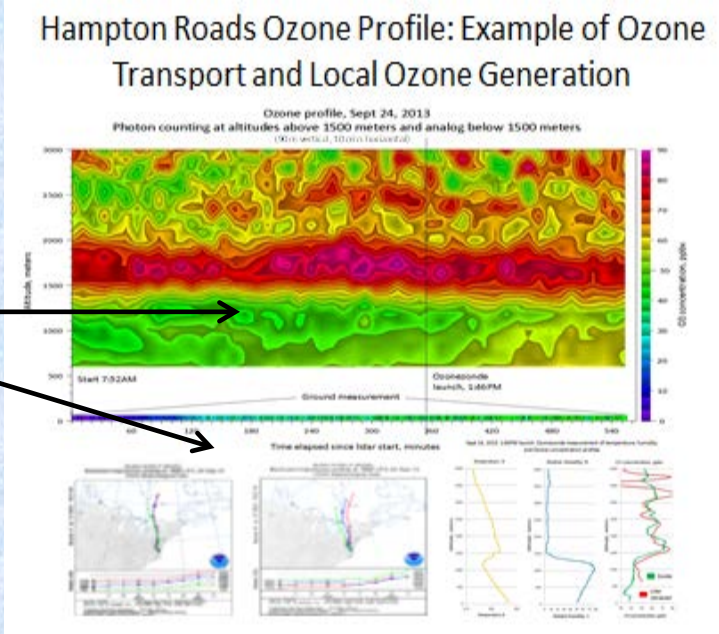


TCCON

Troposopheric Ozone LIDAR Network: TOLNet

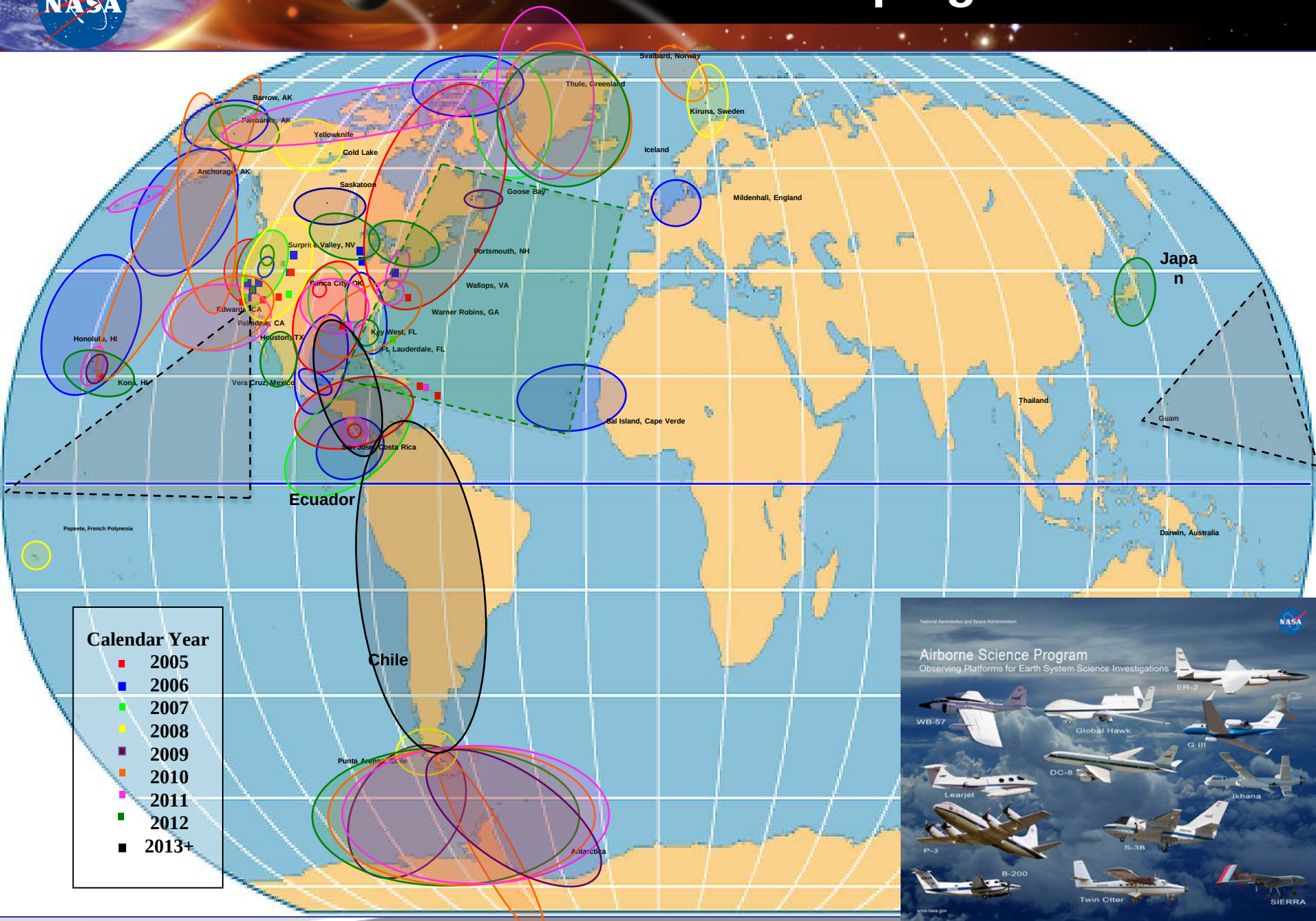
- **JPL:** Instrument operational at Table Mountain Facility since 1999; Record measurement low altitude of 57 m (experimental) and 94 m (routine) above ground achieved in 2013; more frequent measurement starting January 2014.
- **ESRL:** Deployed to Houston in August-September 2013 for SEAC4RS and DISCOVER-AQ; preliminary data available at http://www.esrl.noaa.gov/csd/groups/csd3/measurements/discoveraq/. Plan to characterize stratosphere-troposphere transport of ozone in the Colorado Front Range area in spring 2014. In July and August 2014, the instrument will be deployed in the Boulder, CO area during DISCOVER-AQ and FRAPPE.
- **UAH:** Made extensive observations to support 2013 SEAC^{4}RS and SENEX; provided (7 days) coordinated ground-based measurements for NASA DC8 observations; hosted the U. Wisconsin HSRL for additional aerosol information.
- **GSFC:** Lidar operational and retrieving ozone profiles from 300 m to 10 km ASL as of September 2013, with ozonesonde validations from nearby Beltsville, MD. The trailer is currently being fitted for transport for the NASA DISCOVER AQ mission in 2014.

Sept. ozone curtain plot showing ozone transport from DC above boundary layer with local ozone below boundary layer

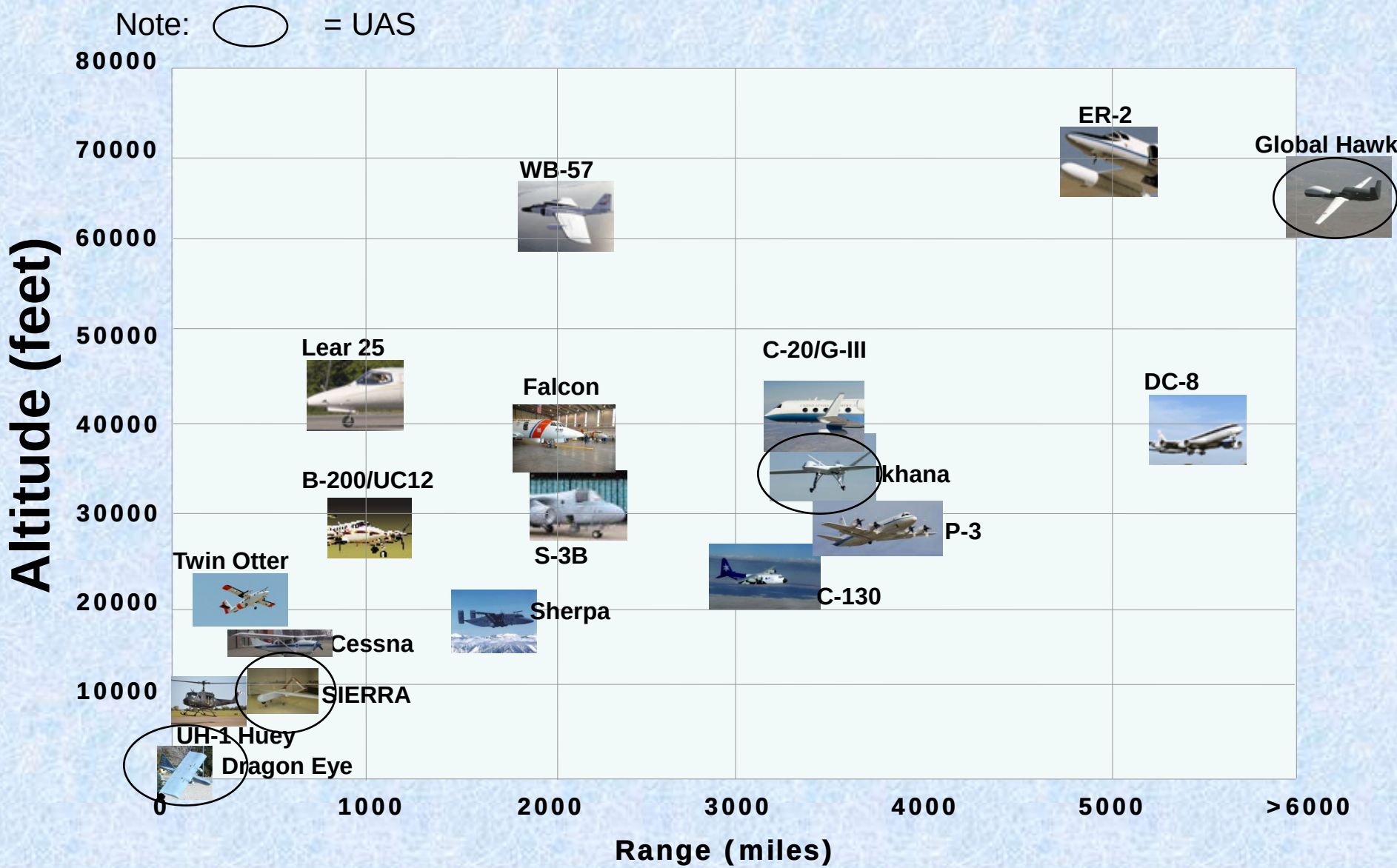


- **LaRC**: Mobile lidar is routinely taking ozone data and comparing to ozonesondes resulting in meaningful science (see above). In February, the lidar will be deployed in the trailer and hardened in preparation for deployment to DISCOVER-AQ Denver summer 2014.

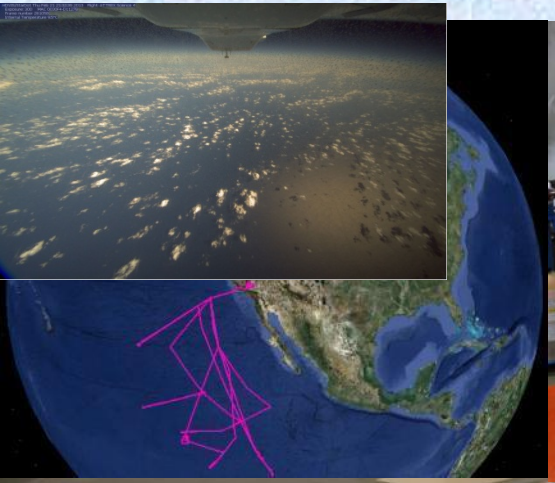
2005-2013 Airborne Campaigns

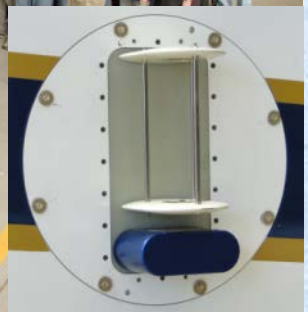


NASA Earth Science Research Capable Aircraft



Earth Venture-1: Airborne Tropical Tropopause Experiment (FY 10 – 15)





- The Airborne Tropical Tropopause Experiment (ATTREX) investigation addresses uncertainties in our knowledge of the climate system by improving our understanding of the processes that control water vapor and changes in ozone in the Tropical Tropopause Layer

- Uses one Global hawk with a suite of instruments that measure water vapor, the size/shape of cirrus cloud particles, winds in three dimensions, the movement of reactive halogen-containing compounds, and bromine-containing gases to improve our understanding of stratospheric ozone

- ATTREX operates from NASA's Dryden Flight Research Center (DFRC) and Guam

- Flew 71 flight hours in FY12, 153 flight hours in FY13 and plan on 300 flight hours in FY14 (currently in Guam flying!)

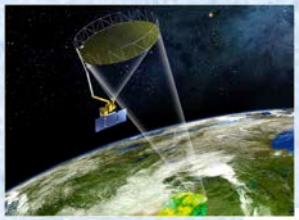
Your Planet is Changing

Earth Right Now

We're on it!

2014

February **April** **July** **August** **November**



GPM **ISS-RapidScat** **OCO-2** **CATS** **SMAP**