NOAA Monitoring to Support Greenhouse Gas Management Strategies

An emerging plan for the next 10 years and beyond

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(NESDIS/STAR)

An emerging challenge for US and world

- Society is going to be making efforts to reduce CO_2 emissions – probably sooner than later
- These efforts will be regional & sectoral in nature, and diverse in their approach
- No large-scale emission reduction effort has succeeded without verification
  - Stratospheric Ozone
  - Acid Rain
  - Regional Air Quality
- The complexity & variability of the carbon cycle make this a challenging issue

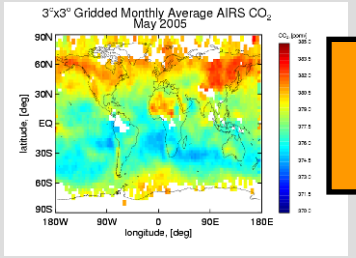
CEOS Carbon Thread

SIT-23
March 4-5, 2009
Cocoa Beach, Florida

Societal Benefit

What knowledge of CO2 sources and sinks, including industrial emissions, land use changes and climate change feedbacks is necessary to ensure effective policy decisions by individual nations?

Decision Topic

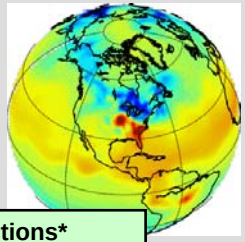


Information Products and Services

- Global Carbon Maps
- Fluxes of CO2 on a regional basis

→ Deforestation Reports

→ Regional Emission Reports



Science Knowledge and Models

- High resolution atmospheric transport models
- Ensemble biospheric modules
- Fossil fuel emission inventories
- Surface fluxes optimized using surface-based and remote measurements.

→ CarbonTracker and other Reanalysis Products

Satellites, Aircraft, Ground-based, Towers

Measurements

OCO, GOSAT, IASI, AIRS, ASCENDS

Surface and aircraft flasks
Carbon flux towers
Solar occultation FTS instruments,

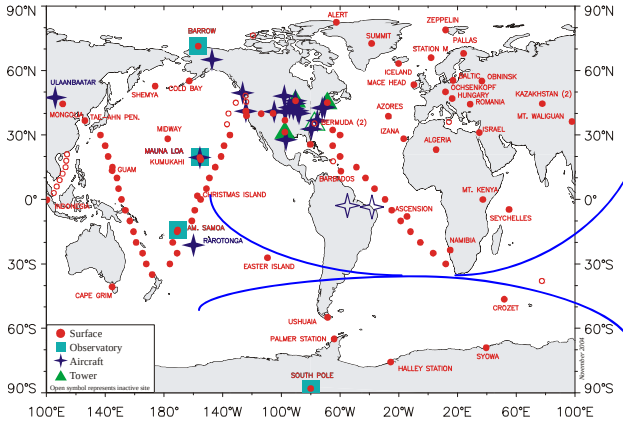
Instruments and Missions

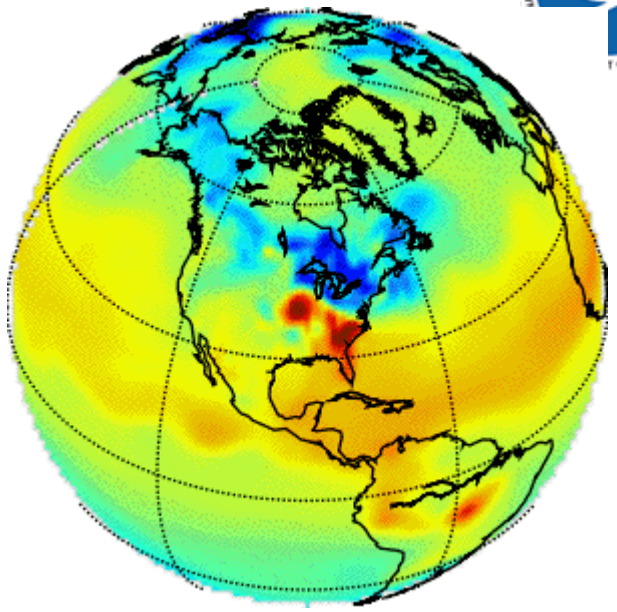
Relevant GEO Tasks and CEOS Actions*

- CL-09-03 Global Carbon Observation and Analysis System
  a) Integrated Global Carbon Observation (IGCO) (former EC-06-01)
- b) Forest Carbon Tracking
- c) Global Monitoring of Greenhouse Gases from Space
- AR-09-03 Advocating for Sustained Observing Systems
  AR-09-03a_11* Global carbon dataset

Contacts: Goldberg, Butler, Barnet (NOAA), Moriyama (JAXA), Briggs (ESA), Husband (EUMETSAT), Berrien Moore, Hilsenrath Jucks, Miller (NASA) Per Erik Skrovseth (NSC), Alex Held (CSIRO), Simmons (ECMWF), Denning , GCOS (Bojinski)

CarbonTracker
(carbontracker.noaa.gov)





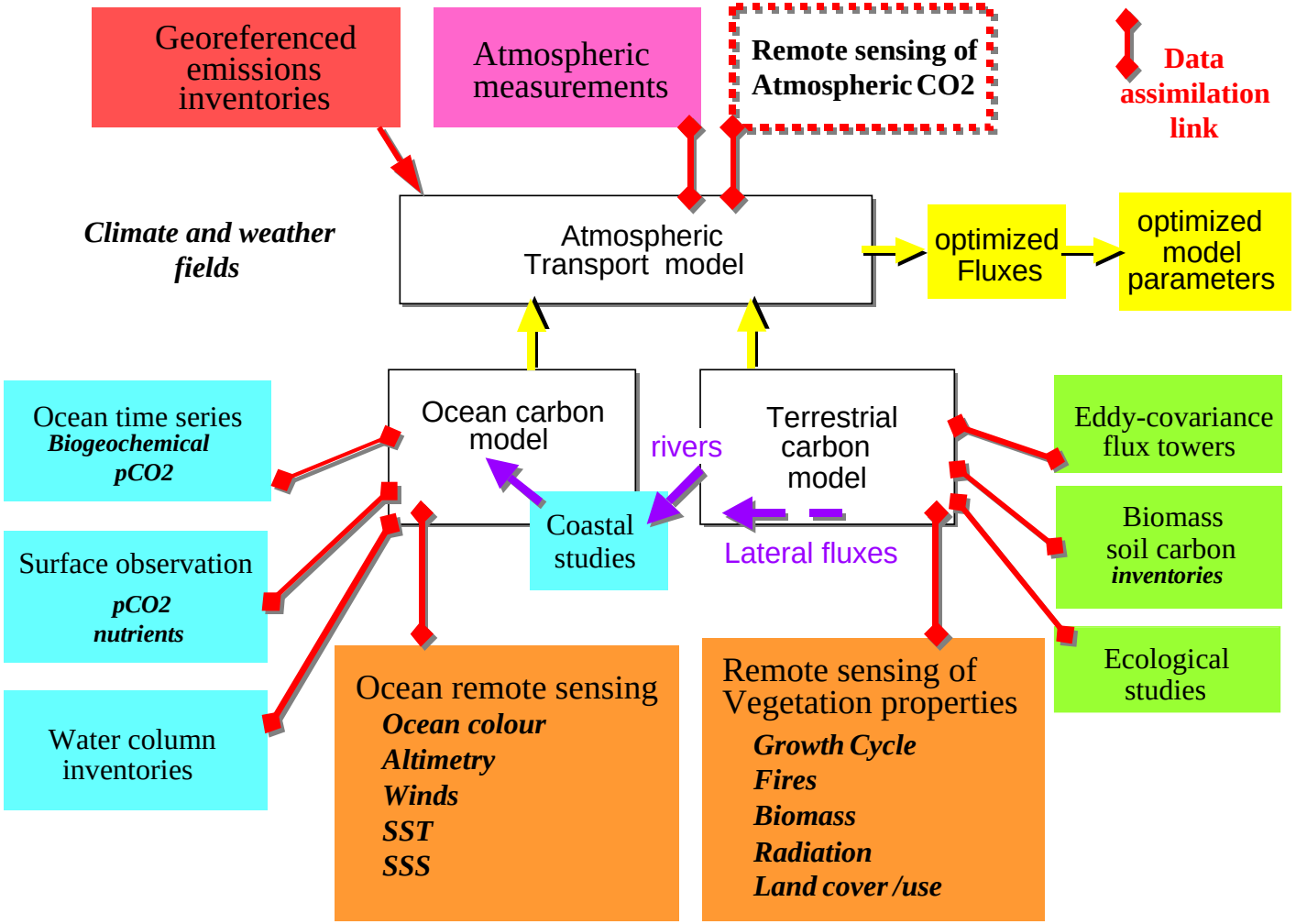
Inversion
Analysis

Observations

Accounting

Atmospheric CO_2 Account		10^{15} grams of carbon per year*
Date	**Origin**	**Balance**
annual	Biosphere	− 3
annual	Ocean	− 2
annual	Fossil Fuel Burning	+ 7
annual	Deforestation	+ 2
Annually Reported Atmospheric Balance		**+ 4**

* These numbers are approximate and are for the whole globe

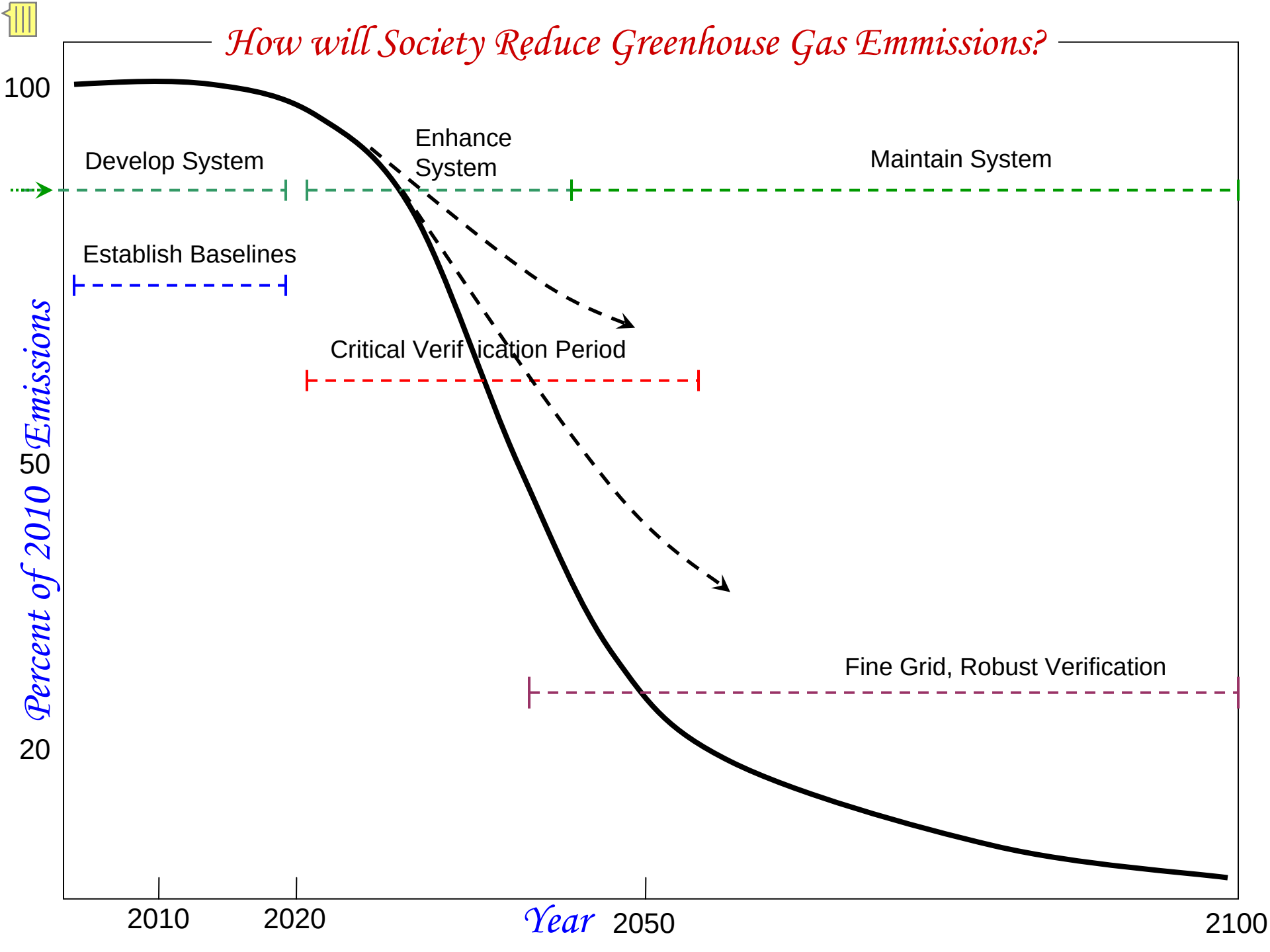


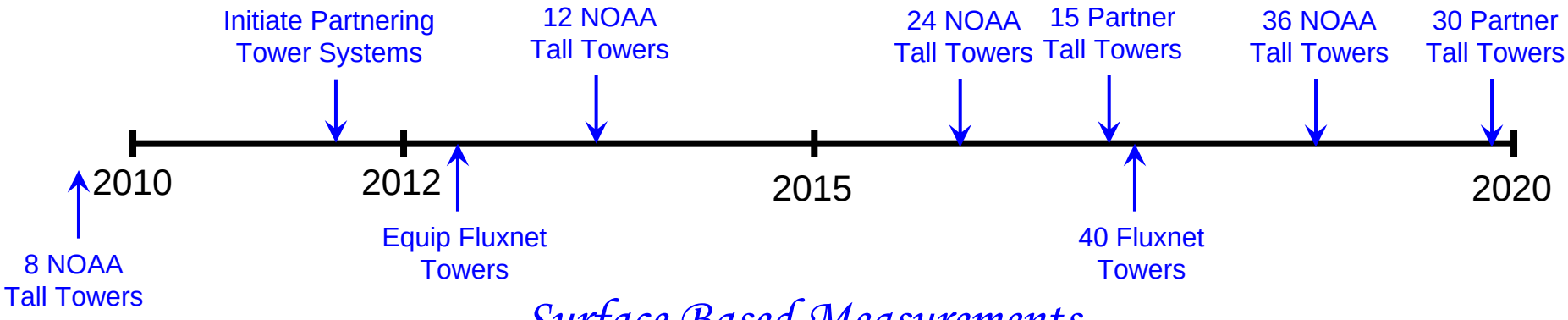
Adapted from B. Moore IGOS

For Regional Scale Resolution and Lower Uncertainty . . .

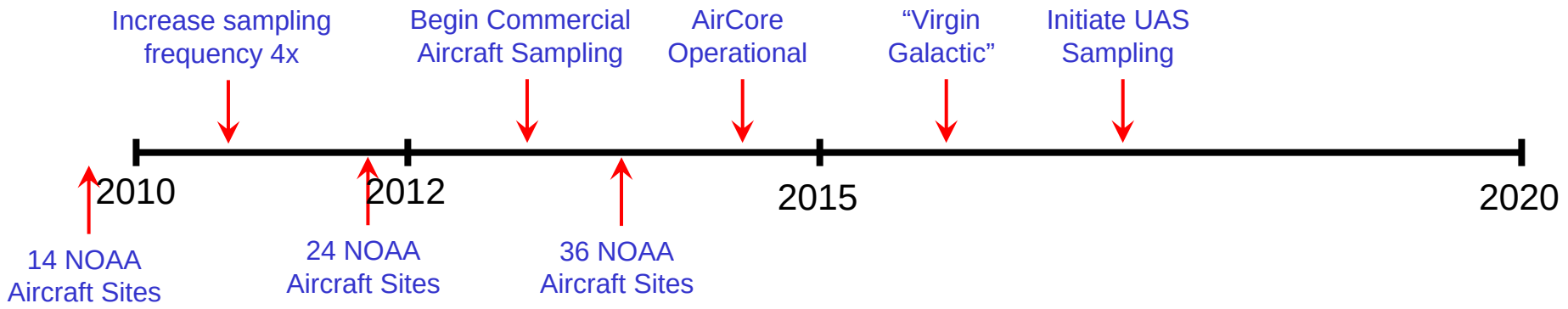
- More Observations (x 10?)
  - Atmosphere
  - Ocean
  - Terrestrial
  - Satellites
  - Improved Instrumentation
- Improved Modeling to Serve Smaller Footprints
  - Transport (÷ 10?)
  - Assimilation, Inversion, Diagnosis
  - Prediction
- Enhanced Computing Capacity

QA/QC, Data Management


How will Society Reduce Greenhouse Gas Emmissions?
100
50
20
Percent of 2010 Emissions
Develop System
Enhance System
Maintain System
Establish Baselines
Critical Verification Period
Fine Grid, Robust Verification
2010
2020
Year
2050
2100

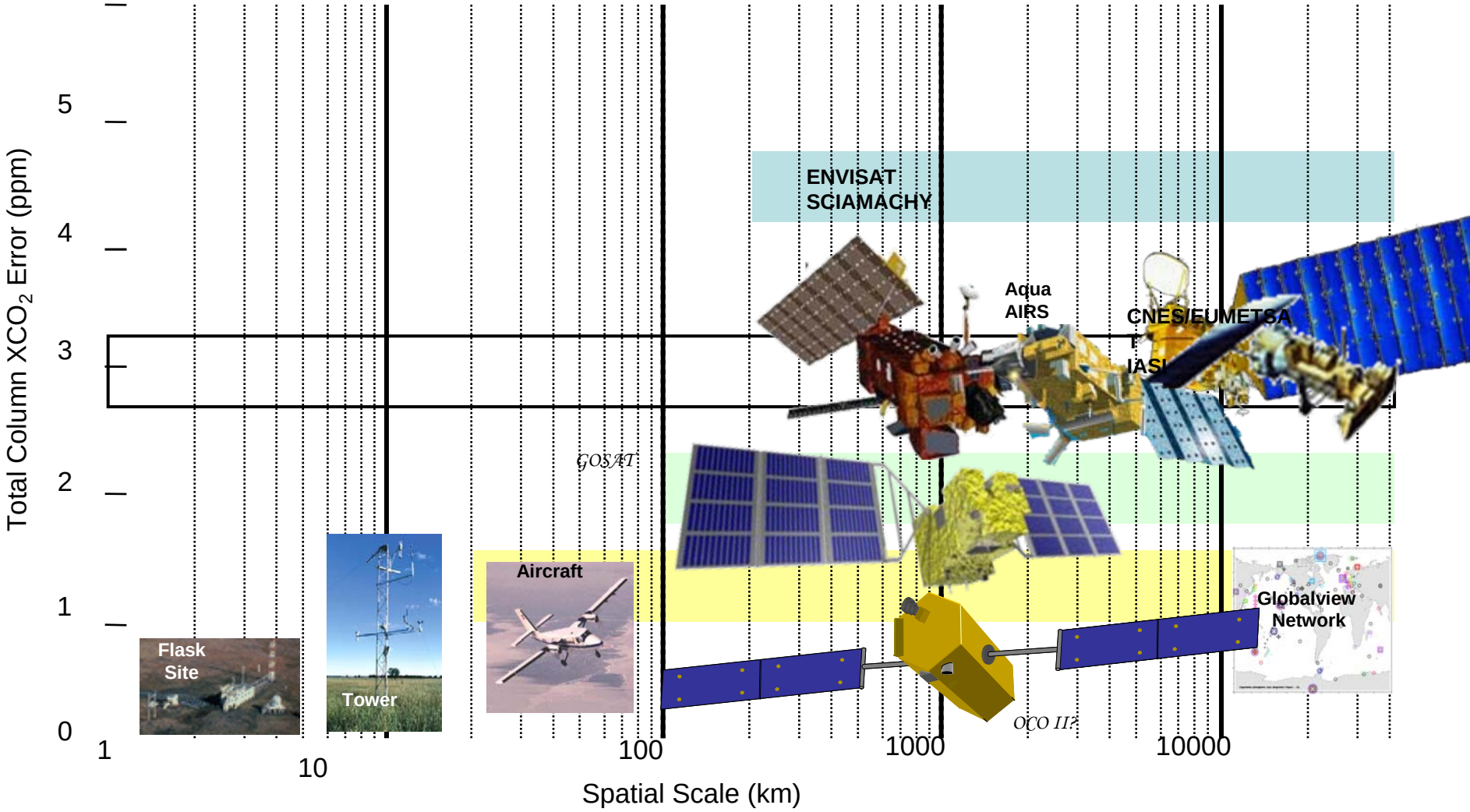


Surface Based Measurements



Aircraft Measurements

Satellite retrievals of carbon fill gaps in scale left by the current surface/tower/aircraft in situ and flask sampling network.



Adapted from D. Crisp

GCOS-IP 2010 for CO2 and CH4

Satellite measurements are emerging as an important component of the overall observing system for CO_2 and CH_4. The SCIAMACHY instrument made the first global measurements of CH_4, and its data are being used in inverse modelling studies to quantify CH_4 emissions. The AIRS and IASI high-resolution IR sounders are providing information on both CO_2 and CH_4, though with limited vertical range, and their data too have been used in flux inversions via data assimilation. The recently launched GOSAT mission is starting to provide more complete information. Experience with the use of the data from GOSAT will guide the development of the space-based component of the observing system for these two majors GHGs.

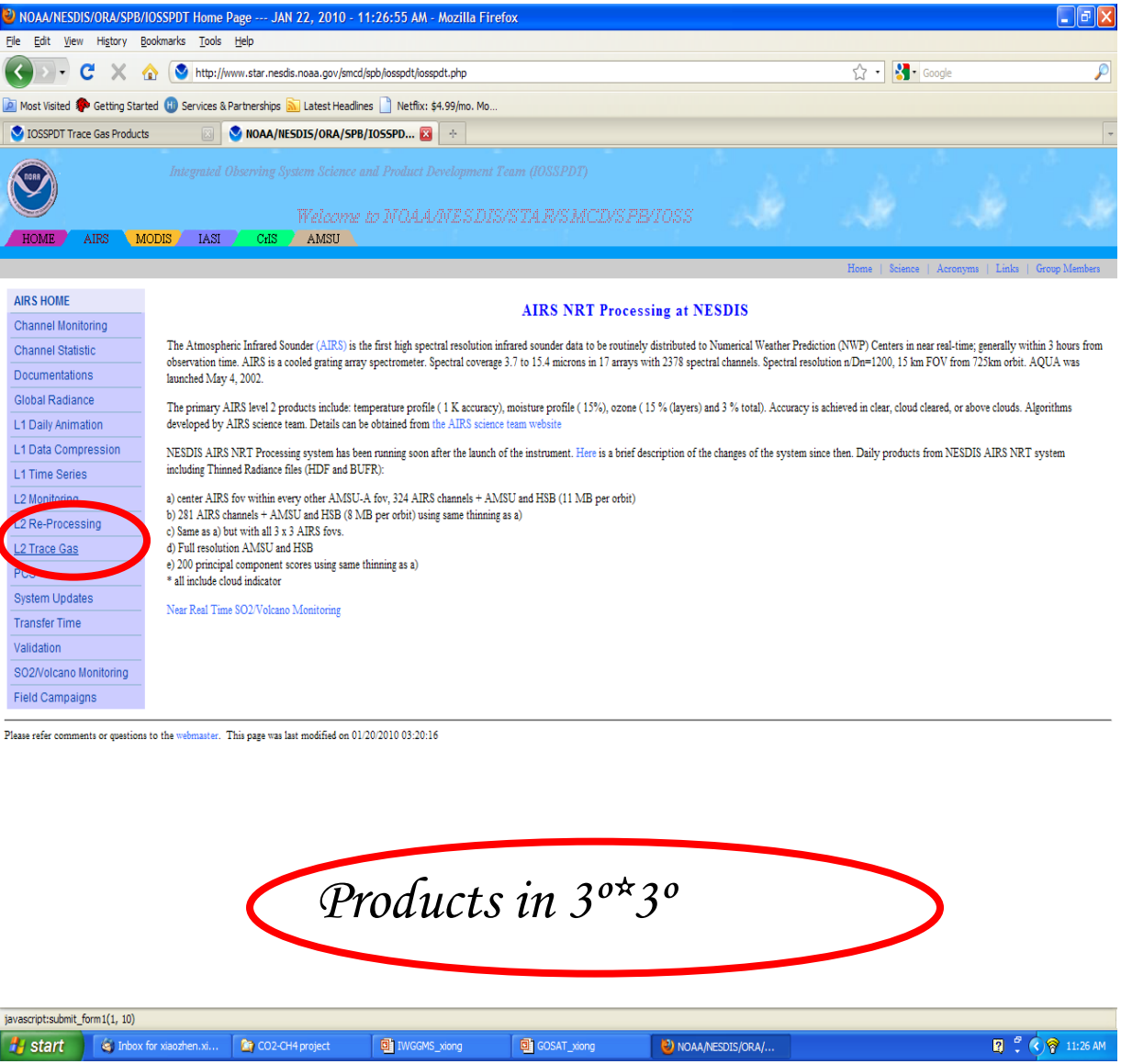
Action A28

Action: Assess the value of the data provided by current space-based measurements of CO_2 and CH_4, and develop and implement proposals for follow-on missions accordingly.
Who: Parties' research institutions and Space agencies
Time-Frame: Urgent, to minimise data gap following GOSAT
Performance Indicator: Assessment and proposal documents; approval of consequent missions
Annual Cost Implications: 1-10M USD initially, increasing with implementation (10% in non-Annex-I Parties).

NESDIS: Key area is validation, error characterization

For more information:

http://www.star.nesdis.noaa.gov/smcd/spb/iosspdt/iosspdt.php



Trace GAS web-pages allow a quick look at the trace gas products as a function of geography, time, and comparisons with *in-situ* datasets.

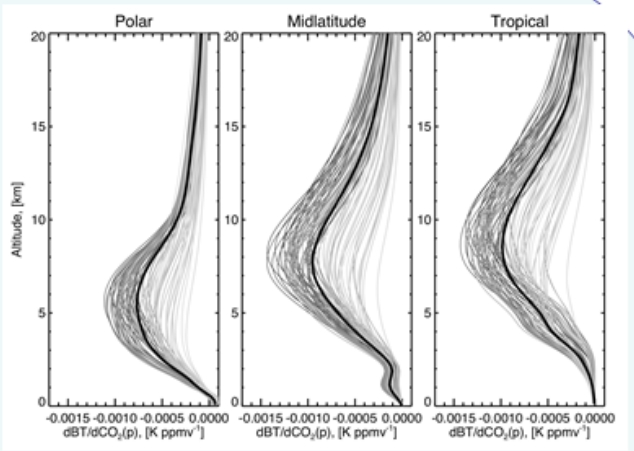
USERID & PASSWORD

Request via e-mail:

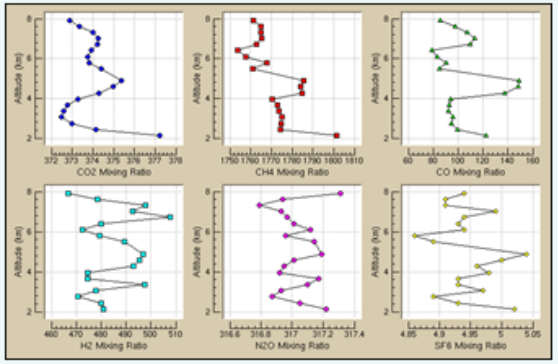
Xiaozhen.xiong@noaa.gov

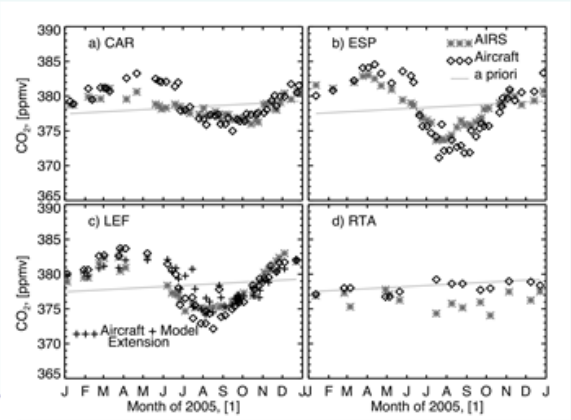
Validation

Thermal sounders, such as AIRS, IASI, and CrIS, measure traces in a thick tropospheric column averages. The vertical region sounded is a function of the atmospheric state as shown at right for CO2



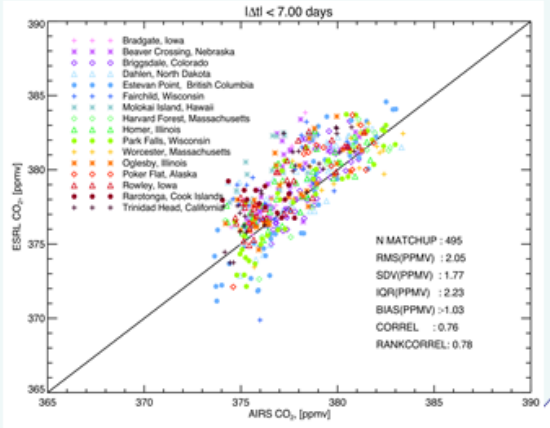
The best in-situ validation products are gas flask samples taken during aircraft flights. The NOAA/ESRL monitoring network provides high precision vertical profiles for a number of locations



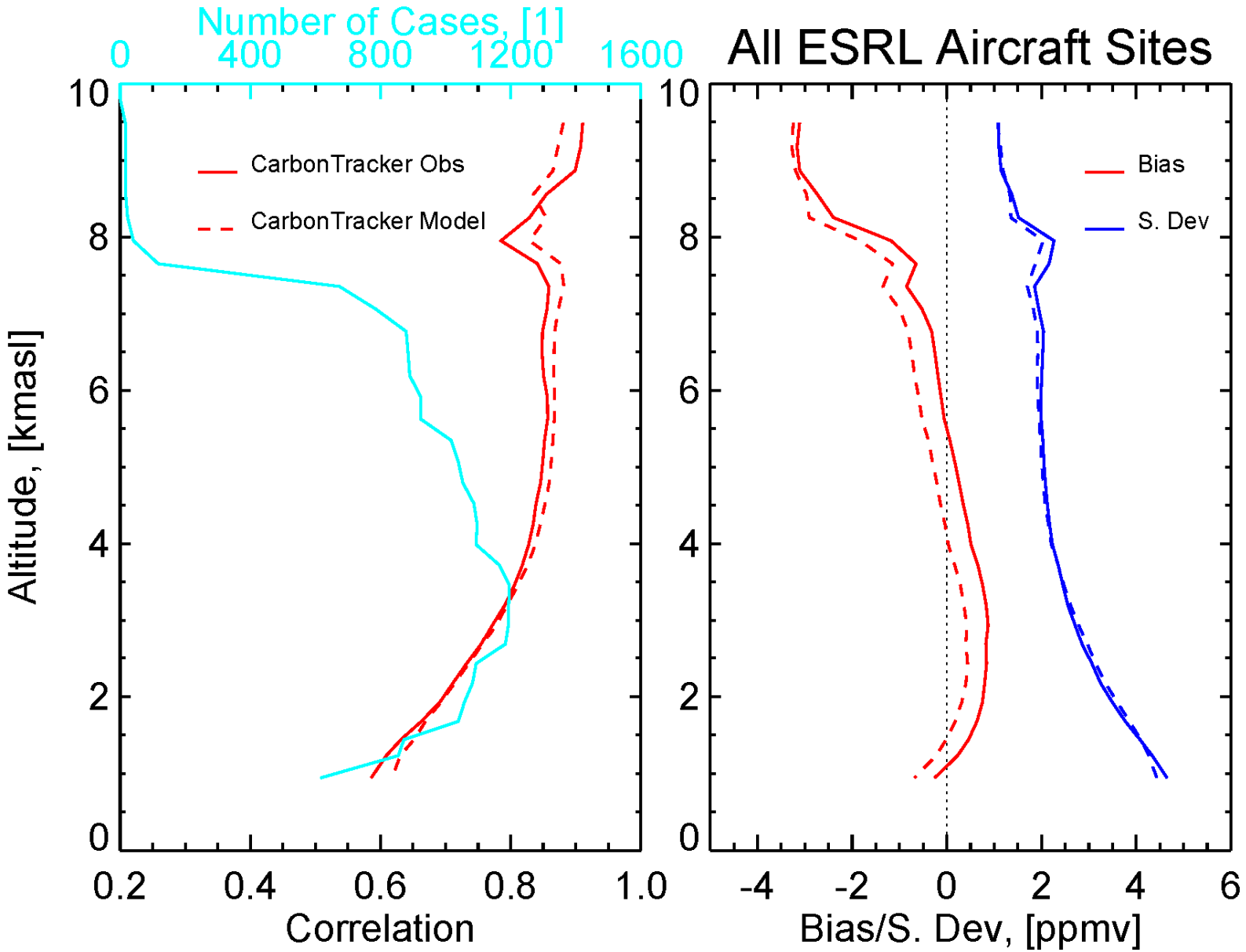


Comparison of AIRS CO2 product with aircraft measurements at 4 ESRL sites shown as a function of time (left)

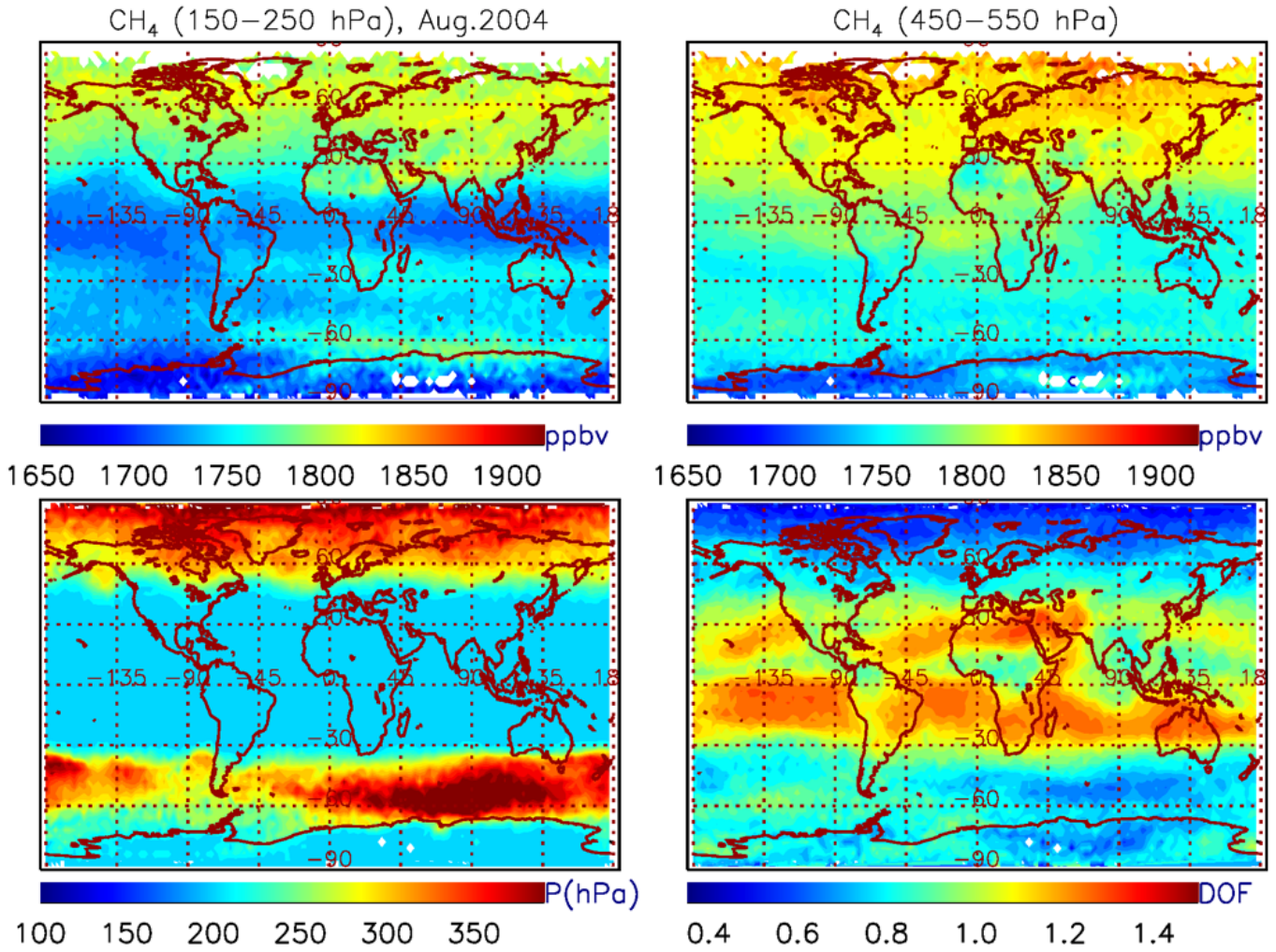
and as a scatter plot for all ESRL sites (right)



Comparison of AIRS Retrievals (+0.64 ppmv/yr correction) w/ NOAA/ESRL/GMD Aircraft (Obs) and CarbonTracker (Model) CO2



AIRS Provides Middle/Upper Tropospheric CH4 Information



Peak Pressure of Sensitivity

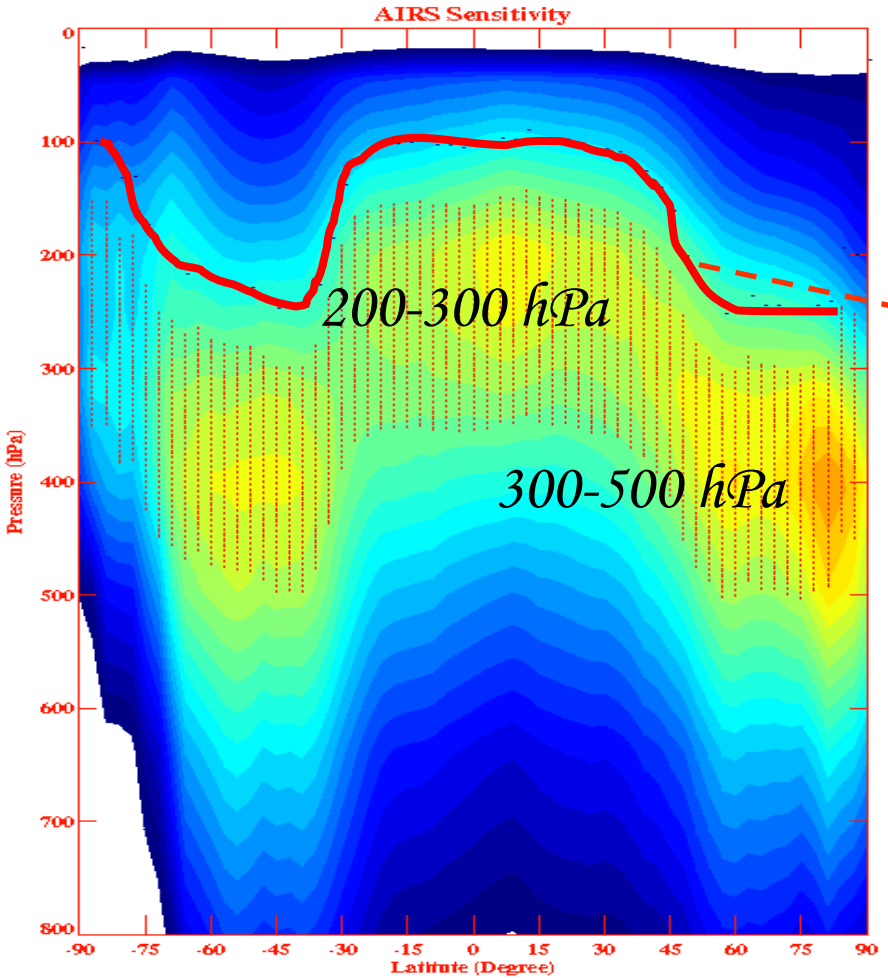
Degrees of Freedom

Xiong et al., JGR-B, 2007

Most sensitive layers of AIRS to CH4

(mapping based on area of averaging kernels)

AIRS CH_4
DOF ≈ 1



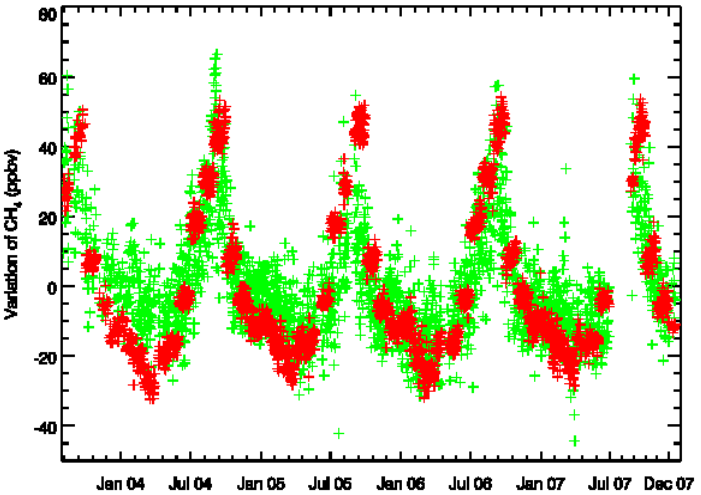
Thermal Tropopause

"Effective Layers"
50 ~ 250 hPa
below Tropopause

Xiong, X., C. Barnet, J. Wei, and E. Maddy, Information-Based Mid-Upper Tropospheric Methane Derived from Atmospheric Infrared Sounder (AIRS) and Its Validation, ACPD, V9, 4, 2009, pp.16331-16360

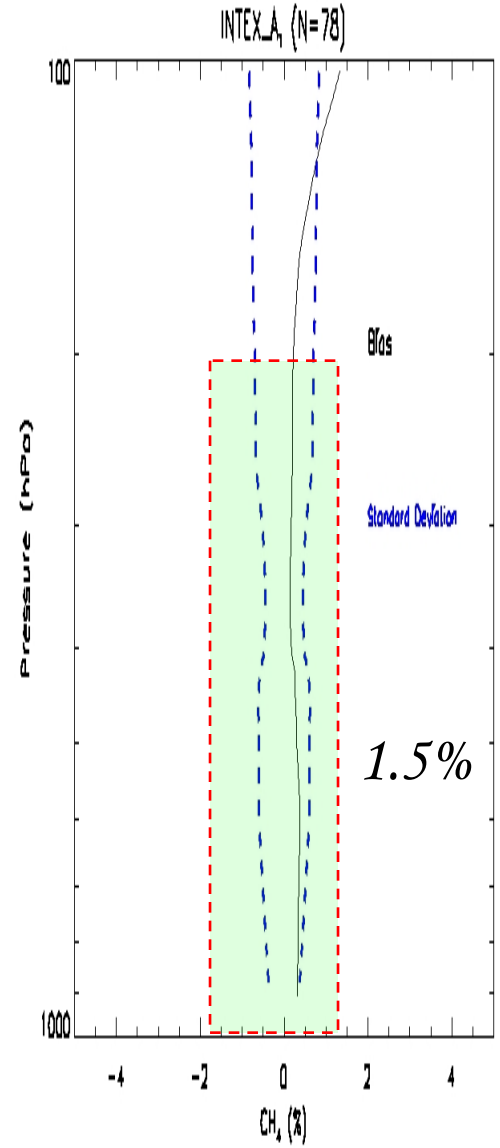
AIRS observes methane variability over Asia

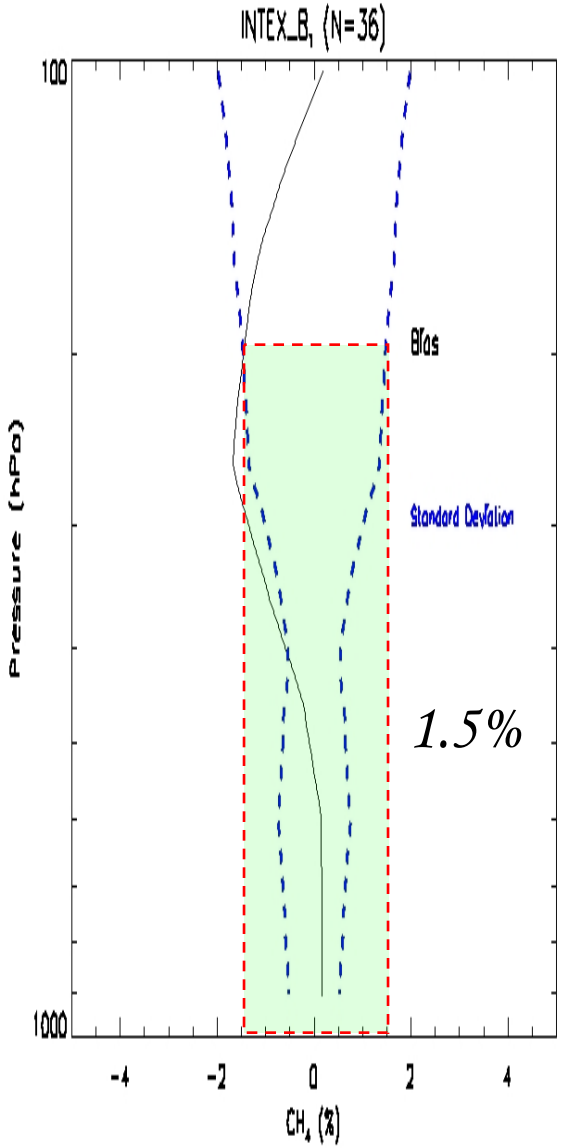
- Enhancement in AIRS methane product is seen in summer months over Asia.
  - Green points is the AIRS methane product
  - Red points are TM3 model provided by Sander Houweling, SRON
- Model agreement suggests methane is transport of local emissions during monsoon season.
- Evidence of strong transport from surface to mid-troposphere.

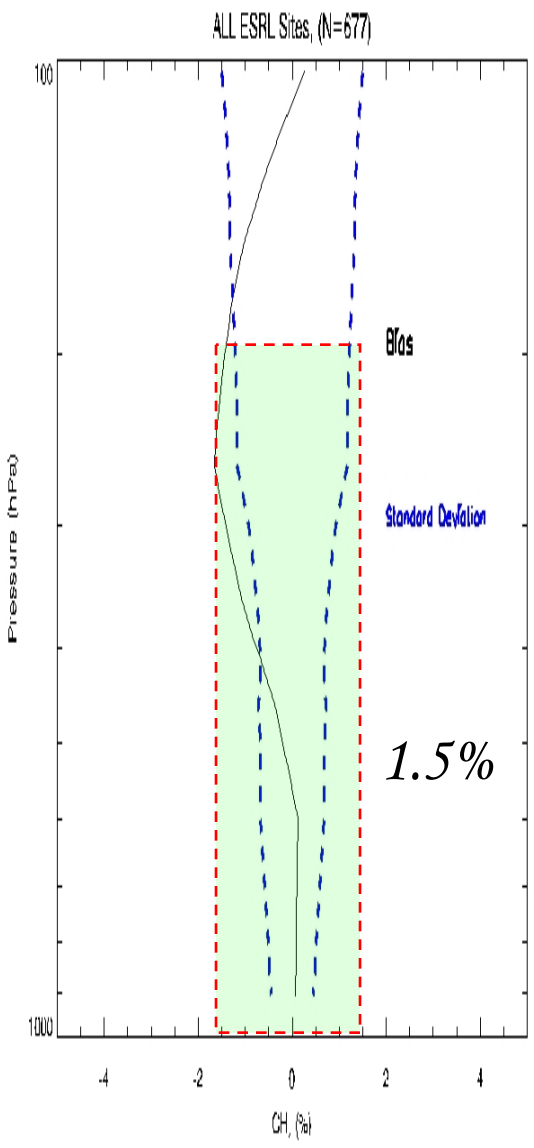


Xiong, X., S. Houweling, J. Wei, E. Maddy, F. Sun and C. Barnet, 2008: *Methane Plume over South Asia during the monsoon season: satellite observation and model simulation.* Atmos. Chem. Phys. 9, p.783-794.

Comparison of AIRS Retrievals w/ Aircraft measurements CH4



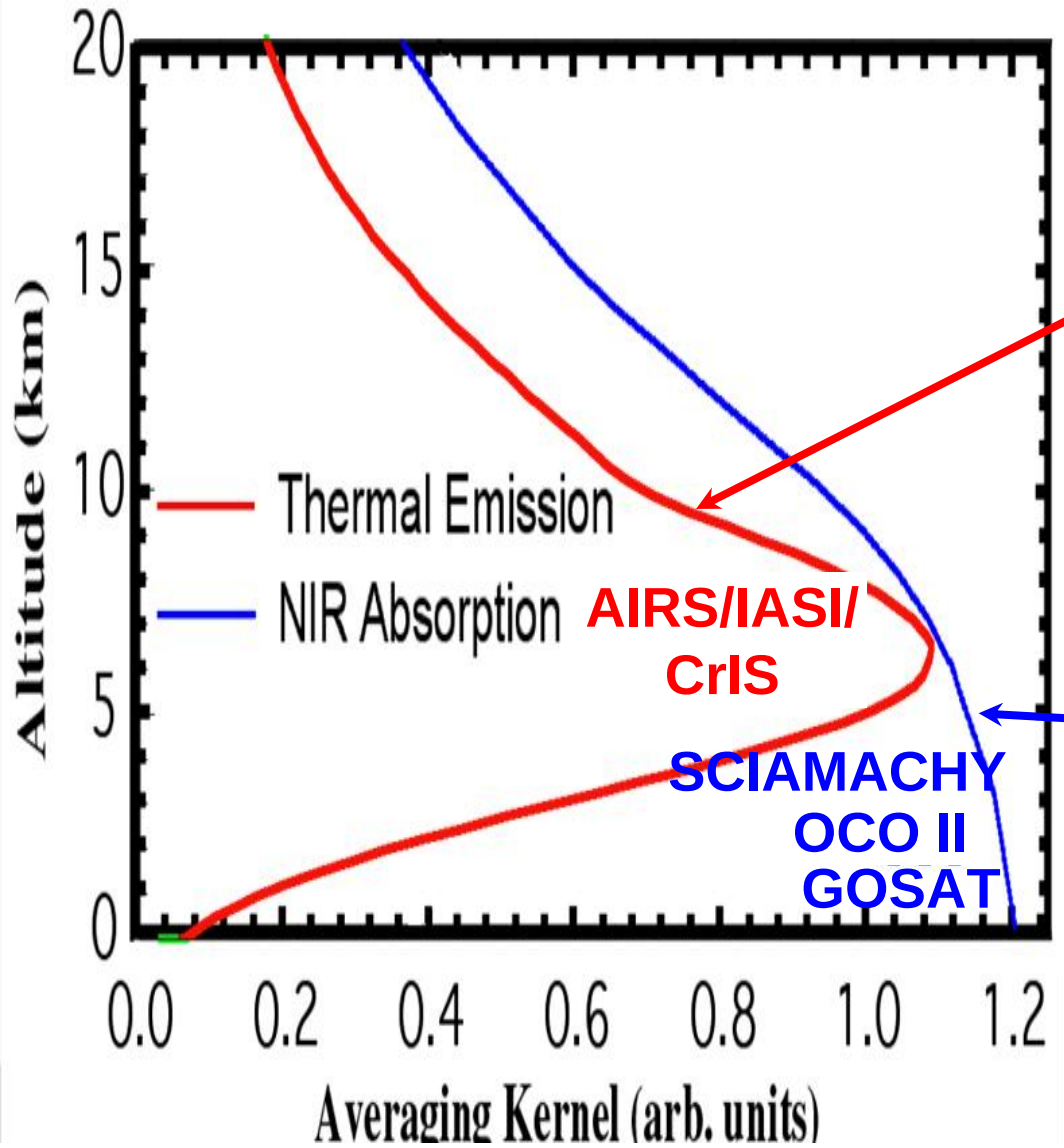




NOAA Proposal to JAXA Second Research Announcement

- To provide cross-validation of GOSAT/TANSO products with NOAA/NESDIS/STAR operational AIRS and IASI products
- To improve the retrieval of total column of CH_4 and CO_2 based solely on TIR measurements.
- To enable a better understanding of the strengths and weaknesses of TIR, SWIR and combined TIR/SWIR retrieval strategies in determining the spatial-temporal variation of CO_2 and CH_4 in the atmosphere.

AIRS/IASI/CrIS thermal IR measurements complement the solar/passive measurements by providing an independent upper boundary condition



- Thermal instruments (e.g., AIRS, IASI, CrIS) measure mid-tropospheric column
  - Peak of vertical weighting is a function of T profile and water profile and ozone profile.
  - Age of air is on the order of weeks or months.
  - Significant horizontal and vertical displacements of the trace gases from the sources and sinks.
- Solar/Passive instruments (e.g., SCIAMACHY, OCO II, GOSAT) & laser approaches measure a lower troposphere weighted total column average.
  - Mixture of surface and near-surface atmospheric contribution
  - Age of air varies vertically.