

# The North American Carbon Program (NACP): Observations, Field Experiments, and Data Assimilation.

## GOAL

Develop scientific knowledge of the quantity of, and processes regulating, emissions and uptake of major gases containing carbon, including the **greenhouse gases**,

**CO<sub>2</sub> and CH<sub>4</sub>**

and the **combustion** tracer

**CO.**

CO<sub>2</sub>, CH<sub>4</sub>, CO

The NACP develops and implements an **integrated system of observations and models** to determine long-term, large scale (regional-continental) surface-atmosphere fluxes of CO<sub>2</sub>, CH<sub>4</sub> and CO, and to understand the processes controlling these fluxes.

## Motivation

- Provide the scientific and technical tools to diagnose current and past contributions of major regions of the earth to atmospheric burdens of greenhouse gases, **impossible hitherto.**

- Enable forecasts of future increases in concentrations of atmospheric CO<sub>2</sub> and CH<sub>4</sub>. *The intent is to provide the scientific information needed to design policies to reduce net emissions of CO<sub>2</sub> and CH<sub>4</sub> to the atmosphere from the US and neighboring countries.*

Provide key data for advancing knowledge in other key scientific areas:

- The foundation for determining large-scale sources and long-range (intercontinental) transport of **air pollutants.**

- Large-scale, timely direct measures of **ecosystem changes, health and productivity** for agriculture, forests, and wild lands.

- Data sets that define atmospheric distributions of CO<sub>2</sub> and transport rates into/out of the Planetary Boundary Layer, to improve **weather forecasts and climate models.**

# The Program

The NACP presents a phased implementation of new research, long-term measurements, and operational observations and analysis in a closely coordinated, integrated Program. The Program develops major initiatives in three key areas:

- Atmospheric measurements;
- Observations, process studies, and modeling of land ecosystems (plants and soils) and ocean margins;
- Models that integrate atmospheric, land, and ocean data, leading to a **bold new paradigm for data assimilation systems to diagnose exchange fluxes between the earth's surface and the atmosphere.**

## Major Program Elements of the NACP

### 1a) Long Term Measurement of Atmosphere, Vegetation, Soil

Using ground-based, aircraft and satellite measurements, obtain spatially/temporally-resolved, three-dimensional data for the major carbon gases, CO<sub>2</sub>, CH<sub>4</sub>, CO, to enable reliable estimates for US/North American sources and sinks of these gases.

### 1b) Intensive field programs

Through large-scale airborne and field campaigns, provide data sets to evaluate and improve network design, test and help develop models to deal with continental data (the "new challenge"), and provide atmospheric "snapshots" to constrain fluxes on different scales and to interface with atmospheric chemistry missions.

## 2. Atmosphere-plant-soil-ocean models

Develop new types of **integrated models to analyze and eventually assimilate the data from the observational elements of the Program** (atmospheric concentrations, meteorological fields, and observations of soils and vegetation), to derive regionally-resolved mass fluxes.

*The NACP data sets will be quantitatively and qualitatively different from current data sets, providing a three-dimensional picture of atmospheric concentrations at frequent intervals. The deduction of surface fluxes from these data requires a new class of models for atmospheric transport, linked to ecosystem, agriculture, forestry and ocean sub-models, that incorporate advanced data assimilation procedures.*

### 3a. Plants, soils, ecosystems, landscapes: observations and sub-models

**Initiate complete carbon accounting for forests, agricultural lands, and currently non-inventoried lands (peatlands, scrub land, suburban landscapes) and sparsely-measured carbon pools (roots, coarse woody debris, shrubs,...).**

*Apply an hierarchical strategy to obtain detailed information for the entire North America, integrating detailed inventories and process studies, flux tower data, and remote sensing. Wetland and agricultural sources of CH<sub>4</sub> require special attention.*

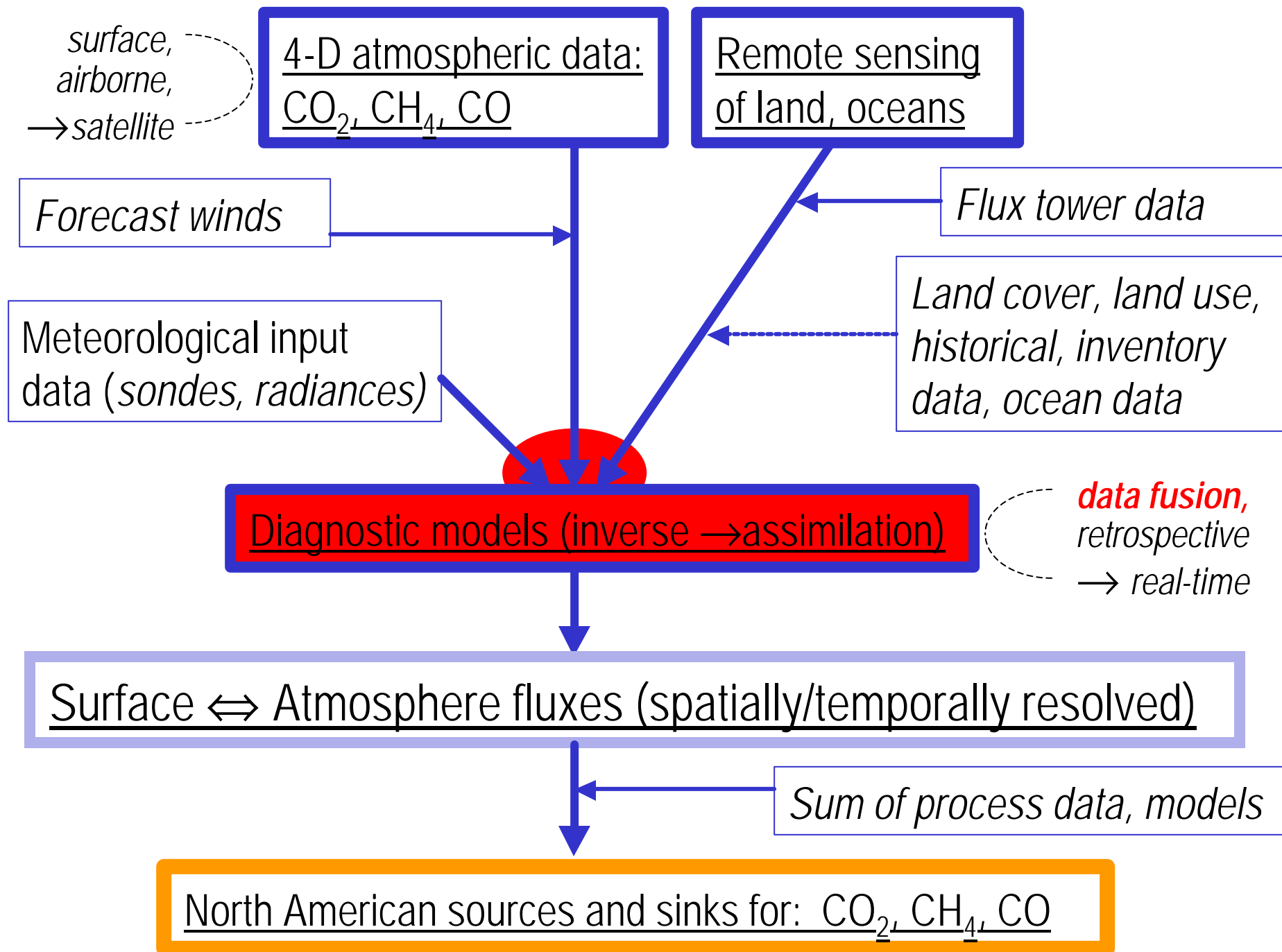
**Develop new classes of models that predict surface-atmosphere fluxes by combining representations of dynamic structure of vegetation and soils with biogeochemical transformations and with environmental data.**

*These models will interface with analyzed wind fields and mesoscale models, and with atmospheric observations, to provide the diagnostic and prognostic capability for assimilated surface-atmosphere fluxes.*

### 3b. Ocean measurements and modeling

**Carry out high resolution measurements of air-sea fluxes of CO<sub>2</sub>, and process studies in coastal waters and adjacent open ocean regions, to define contributions of the ocean margins to the North American carbon budget.**

*These observations will be closely linked to global studies of the marine carbon cycle, and will place North America in the global context to enable "inverse model" estimates of the North American carbon cycle.*



# Synergy

**Atmospheric Chemistry.** Carbon gases ( $\text{CO}_2$ ,  $\text{CH}_4$ ,  $\text{CO}$ ) are intimately associated with the principal sources of air pollution. The NACP will provide spatially/temporally resolved surface-atmosphere fluxes *and* long-range transport fluxes of these critical tracers, also long-term airborne data for key reactive species.

**Resource management and ecological sciences.** The carbon budget of a region is an emergent property defining the health and productivity of ecosystems. NACP data will define the growth trajectories of major crops, the fuel accumulating on fire-prone lands, and the responses of major ecosystems to environmental forcing (e.g. ENSO events).

**Weather forecasting and climate modeling.** The tracer distributions give direct measures of PBL processes, long the bane of forecast models. Data for  $\text{CO}_2$  concentrations and fluxes directly benefit temperature retrievals. Climate feedbacks involving  $\text{CO}_2$  and  $\text{CH}_4$  are major issues for climate projections.

## Deliverables of the NACP

- 1) Measurements of sources and sinks for CO<sub>2</sub>, CH<sub>4</sub>, and CO for North America, at scales from continental (5000 km) to regional (1000 km).
- 2) Identification and quantification of the natural and human processes contributing to the carbon budget, for time scales from seasonal to decadal.
- 3) Documentation of North America's contribution to the Northern Hemisphere carbon sink, place into the global context.**
- 4) Documentation of the effect of land management and land use history on carbon balances.**
- 5) Process understanding necessary to improve future projections of carbon balances fo North America**
- 6) Optimal sampling networks (both in situ and remote) to document current and future sources and sinks of CO<sub>2</sub>, CH<sub>4</sub>, and CO.
- 7) Data assimilation models to compute carbon balances.
- 8) "State of the Carbon Cycle for North America", public reporting.
- 9) Tracer data and observational infrastructure to help advance **atmospheric chemistry** (better determination of sources and transformation of pollutants), **resource management** (improved knowledge of biophysical changes in major ecosystems), and **weather forecasting and climate models** (real-time tracer concentration and flux data, coupled models with greatly improved representations of atmosphere-biosphere coupling, surface energy and mass fluxes).



# Issues for the Workshop

- Assess the objectives and goals of the NACP. Is this the program you think should be proposed?
- Examine the strategy outlined in the Plan. Is it feasible? Where are gaps, weaknesses, strengths?
- Provide input on the Plan. Please be specific and concise.

*Some obvious issues:*

*Help needed to build collaborations with neighboring countries.*

*Involvement of operational weather centers.*

*Instrument development accomplished rapidly.*

*Data management, data system*

*Organizational issues for the enterprise.*

