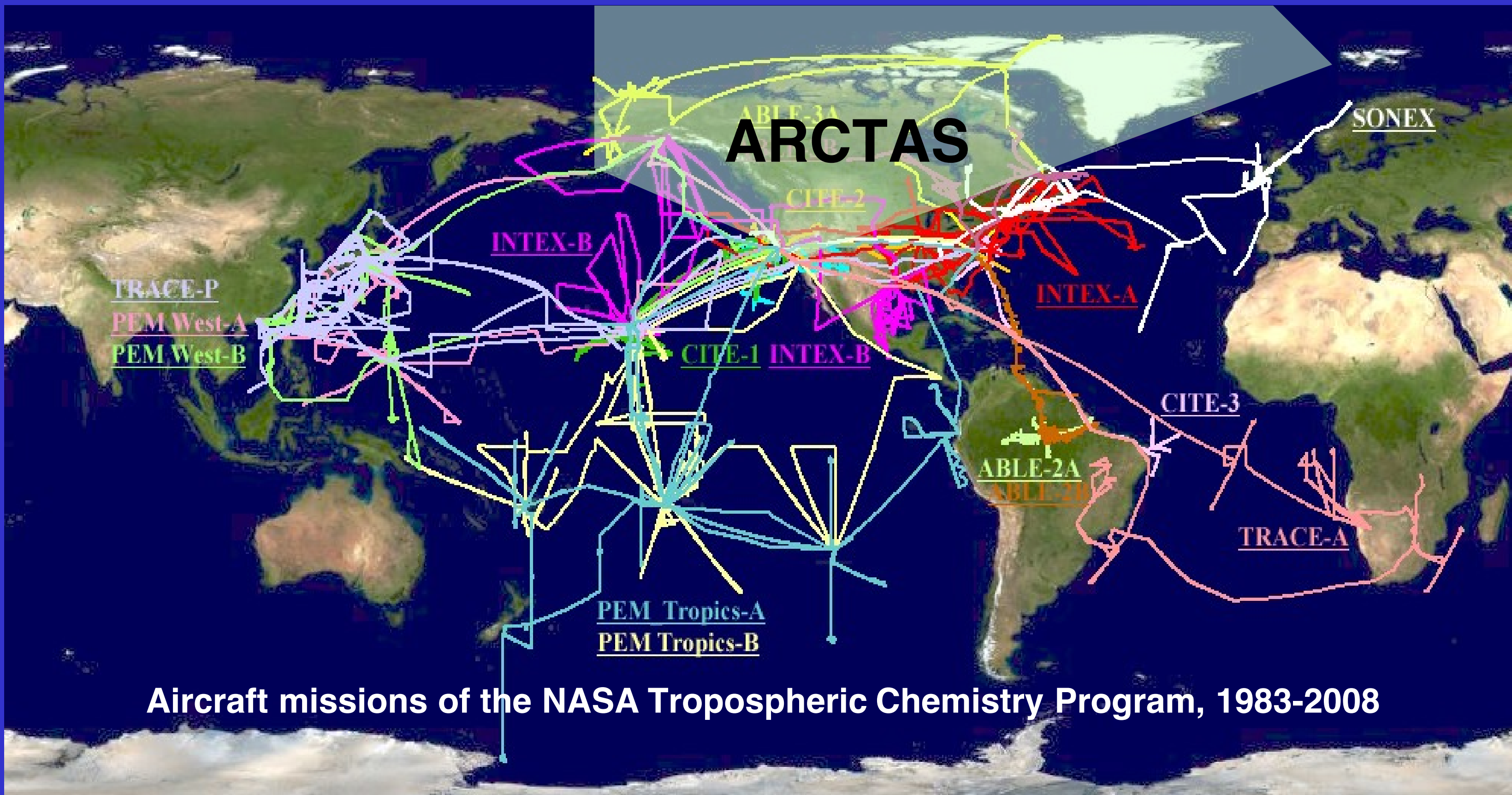
OVERVIEW OF ARCTAS AND SCIENTIFIC OBJECTIVES

Daniel J. Jacob, Harvard University

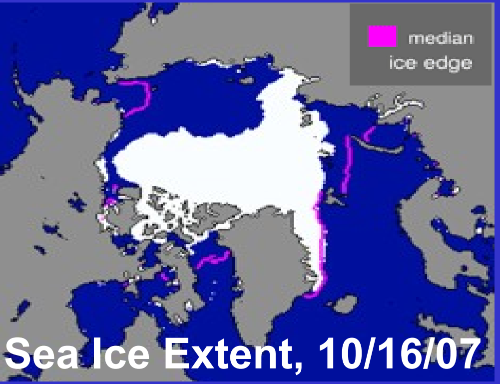
ARCTAS CONTINUES LEGACY OF NASA TROPOSPHERIC CHEMISTRY PROGRAM



Aircraft missions of the NASA Tropospheric Chemistry Program, 1983-2008

- Two 3-week deployments: Apr 1-21 Apr (Fairbanks), Jun 26 – Jul 14 (Cold Lake)
- Three NASA aircraft: DC-8 (in situ chemistry and aerosols, DIAL), P-3 (radiation, in situ aerosols), B-200 (remote aerosols, CALIPSO validation)

URGENT NEED TO BETTER UNDERSTAND ARCTC ATMOSPHERIC COMPOSITION AND CLIMATE



Sea Ice Extent, 10/16/07

ARCTIC IS A BEACON OF GLOBAL CHANGE

- Rapid warming over past decades
- Receptor of mid-latitudes pollution – arctic haze, ozone, persistent pollutants
- Large and increasing influence from boreal forest fires in Siberia and North America

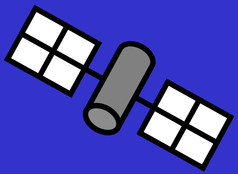
POTENTIALLY LARGE RESPONSE

- Melting of polar ice sheets and permafrost
- Decrease of snow albedo from soot depostion
- Efficient UV/Vis absorption by ozone, soot
- Halogen radical chemistry

UNIQUE OPPORTUNITY FOR NASA

- Large NASA satellite fleet for atmospheric composition and radiation
- Interagency and international collaboration through POLARCAT international atmospheric chemistry field program during IPY
- Broader synergies enabled by other IPY activities (OASIS for oceans, etc.)

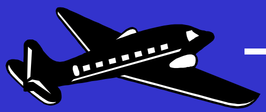
ARCTAS STRATEGY: use aircraft to increase value of satellite data for models of arctic atmospheric composition and climate



Satellite instruments: CALIPSO, OMI, TES, HIRDLS, MLS, MODIS, AIRS, MISR, MOPITT

- Aerosol optical depth, properties
- CO, ozone, BrO, NO_2, HCHO

Aircraft: DC-8, P-3B, B200



- Detailed in situ chemical and aerosol measurements
- Remote sensing of ozone, aerosol, surface properties

- Retrieval development & validation
- Observational error characterization
- Correlative information
- Local chemical & aerosol processes

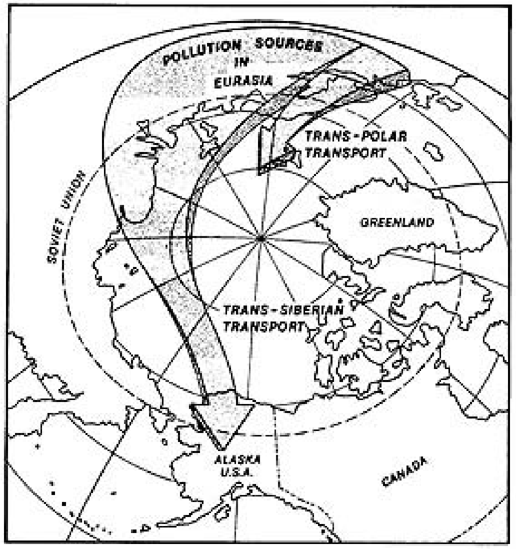
Data assimilation
Diagnostic studies

Models: CTMs, GCMs, ESMs

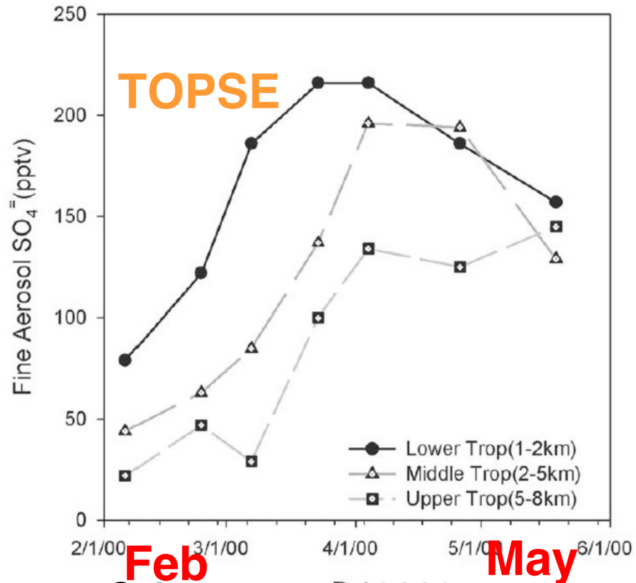
- Source-receptor relationships for Arctic pollution
- Effects of boreal forest fires
- Aerosol radiative forcing
- Arctic chemistry
- Climate response

ARCTAS Science Theme 1:
Transport of mid-latitudes pollution to the Arctic

European influence

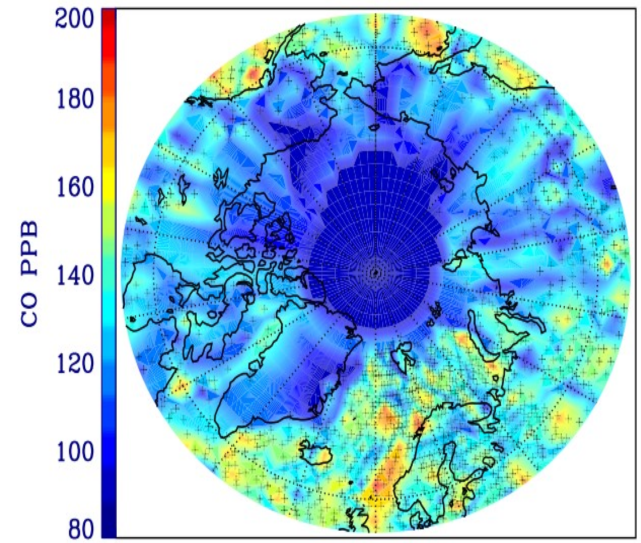


Seasonal sulfate build-up



Scheuer et al., 2003

TES 600 hPa CO, March 2006



J. Worden, JPL

- What are the transport pathways for different pollutants?
- What are the contributions from different source regions, what are the source-receptor relationships?

Satellite capabilities:

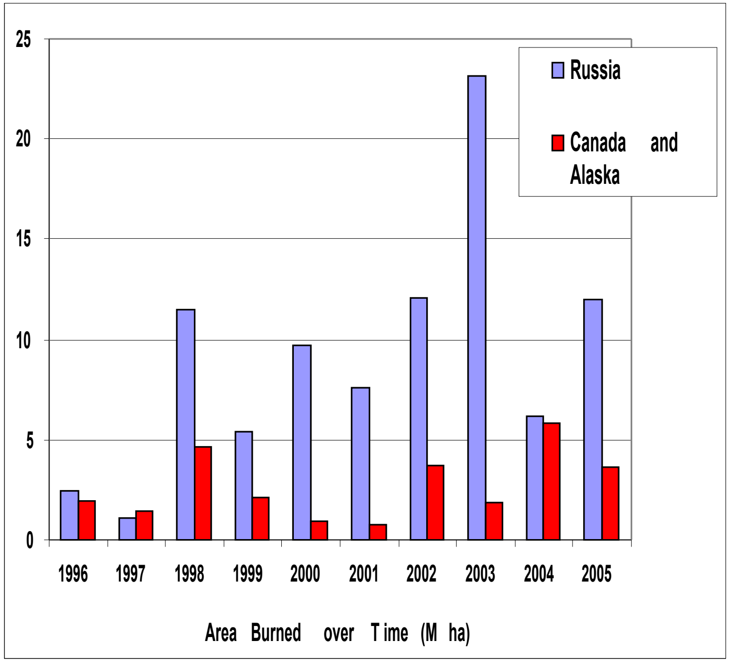
- CO (TES, AIRS, MOPITT)
- Ozone (TES, OMI-MLS)
- aerosols (CALIPSO, MODIS, MISR)
- methane (TES)

Aircraft added value:

- detailed chemical composition
- tracers of sources
- vertical information

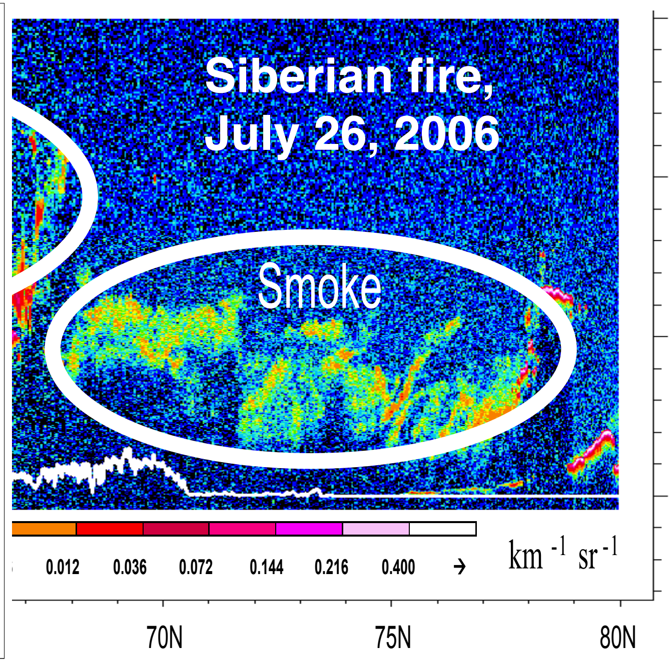
ARCTAS Science Theme 2: Boreal forest fires

Fire trend over past decade



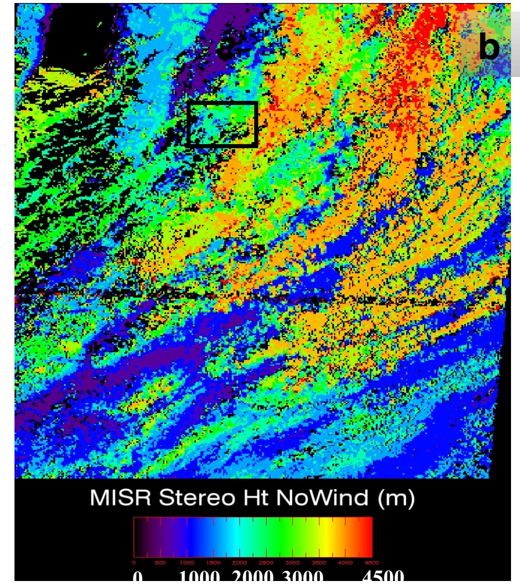
A. Soja, LaRC

CALIPSO view of fire plume



C. Trepte, LaRC

MISR injection height



R. Kahn, JPL

- What are the chemical compositions & evolution of the fire plumes?
- What are their aerosol optical properties, how do these evolve?
- What are the injection heights?
- What are the implications for regional and global atmospheric composition?

Satellite capabilities:

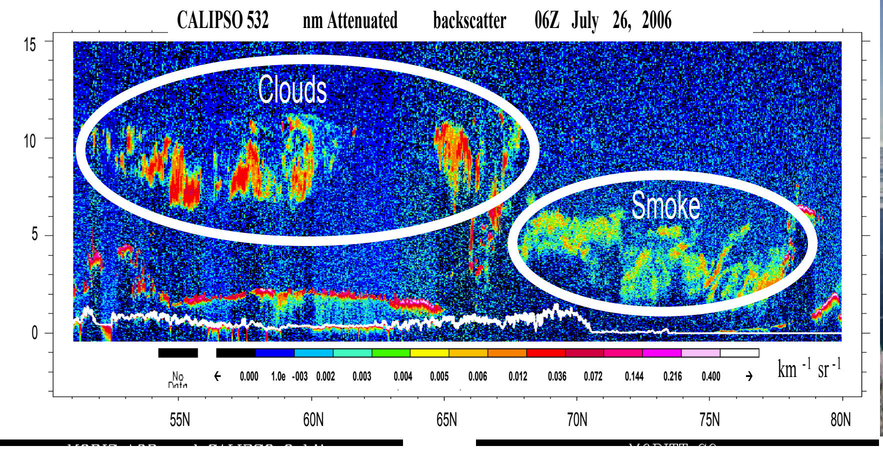
- aerosols (CALIPSO, MODIS, MISR, OMI)
- CO (TES, AIRS, MOPITT, MLS)
- ozone (TES, OMI-MLS)
- methane (TES)

Aircraft added value:

- detailed chemical composition
- aerosol properties
- pyroconvective outflow

ARCTIC Science Theme 3: Aerosol radiative forcing

CALIPSO clouds and smoke



C. Trepte, LaRC

Arctic haze

MISR true-color fire plume

R. Kahn, JPL

- What is the regional radiative forcing from Arctic haze, fire plumes?
- How does this forcing evolve during plume aging?
- What are the major sources of soot to the Arctic?
- How does soot deposition affect ice albedo?

Satellite capabilities:

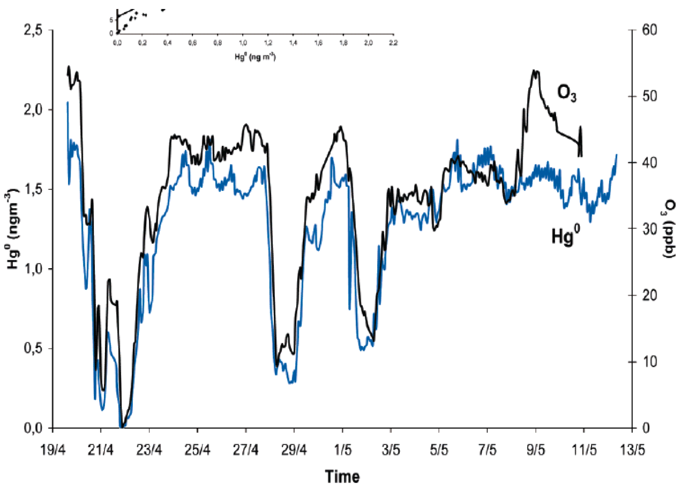
- UV/Vis/IR reflectances (Cloudsat, MODIS, MISR, OMI)
- multi-angle sensing (MISR)
- lidar (CALIPSO)

Aircraft added value:

- detailed in situ aerosol characterization
- remote sensing of radiances, fluxes
- BRDFs

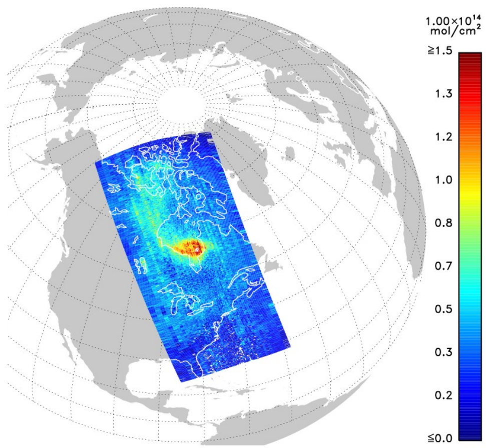
ARCTAS Science Theme 4: Chemical processes

Ozone, Hg depletion events



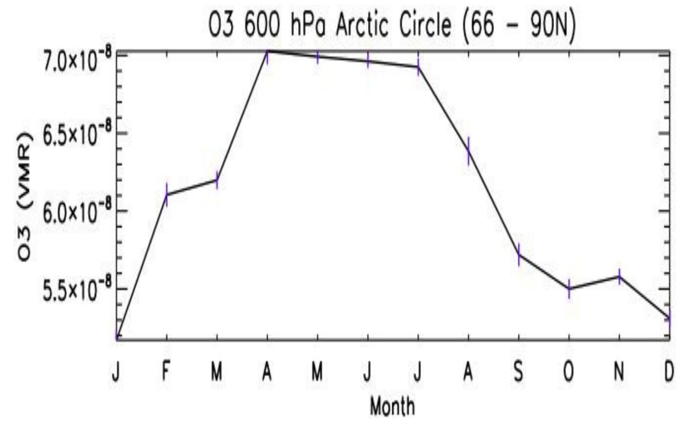
Sprovieri et al. [2005]

OMI tropospheric BrO



K. Chance, Harvard/SAO

TES tropospheric ozone



J. Worden, JPL

- What controls HO_x-NO_x chemistry in the Arctic?
- What drives halogen radical chemistry in the Arctic, what is its regional extent?
- What are the regional implications for ozone, aerosols, mercury?
- How does stratosphere-troposphere exchange affect tropospheric ozone in the Arctic?

Satellite capabilities:
- Ozone (TES, OMI/MLS)
- BrO (OMI)
- strat-trop exchange (HIRDLS)
- CO (TES, AIRS, MOPITT)

Aircraft added value:
- detailed chemical characterization, constraints on photochemical models
- validation of OMI tropospheric BrO
- HO_x measurement intercomparison

AIRCRAFT PLATFORMS, PAYLOADS

DC-8: in situ chemistry and aerosols

Ceiling 37 kft, range 4000 nmi, endurance 9 h

Payload: O_3, H_2O, CO, CO_2, CH_4, NO_x and HO_x chemistry, BrO, mercury, NMVOCs, halocarbons, SO_2. HCN/CH_3CN, actinic fluxes, aerosol composition, aerosol mass and number concentrations, aerosol physical and optical properties, remote ozone and aerosol

P-3: radiation and in situ aerosols

Ceiling 30 kft, range 3800 nmi, endurance 8 h

Payload: optical depth, radiative flux, radiance spectra, aerosol composition, black carbon

B-200: aerosol remote sensing and CALIPSO validation

Ceiling 32 kft, range 800 nmi, endurance 3.5 h

Payload: High Spectral Resolution Lidar (HSRL)
Research Scanning Polarimeter (RSP)

SPRING DEPLOYMENT:
April 1-21, Fairbanks (+ suitcase flight to Thule)

SCIENTIFIC PRIORITIES:

- Asian WCB outflow
- transport and chemical evolution of mid-latitudes pollution
- Arctic haze aerosol chemical and optical properties
- aerosol radiative forcing from Arctic haze
- HO_x-NO_x-halogen chemistry and implications for ozone, aerosols, mercury

SATELLITE VALIDATION PRIORITIES:

- CALIPSO aerosols
- OMI BrO, ozone
- TES CO, methane, ozone
- MLS ozone, CO, HNO_3
- MODIS, MISR aerosols
- AIRS, MOPITT CO

PRINCIPAL COLLABORATIONS:

- NOAA ARCPAC
- DOE ISDAC
- NSF pre-HIPPO
- NSF Summit
- NOAA ICEALOT

SUMMER DEPLOYMENT:
June 26 – July 14, Cold Lake (+ suitcase flight to Thule)

SCIENTIFIC PRIORITIES:

- Emissions from boreal forest fires
- Aerosol and chemical evolution of fire plumes
- Aerosol radiative forcing associated with the plumes
- Impact of boreal forest fires on regional and global atmospheric composition

  Secondary objectives:

  - *Biosphere-atmosphere exchange of boreal ecosystems*
  - *Emissions from tar sands and local oil/gas extraction*

SATELLITE VALIDATION PRIORITIES:

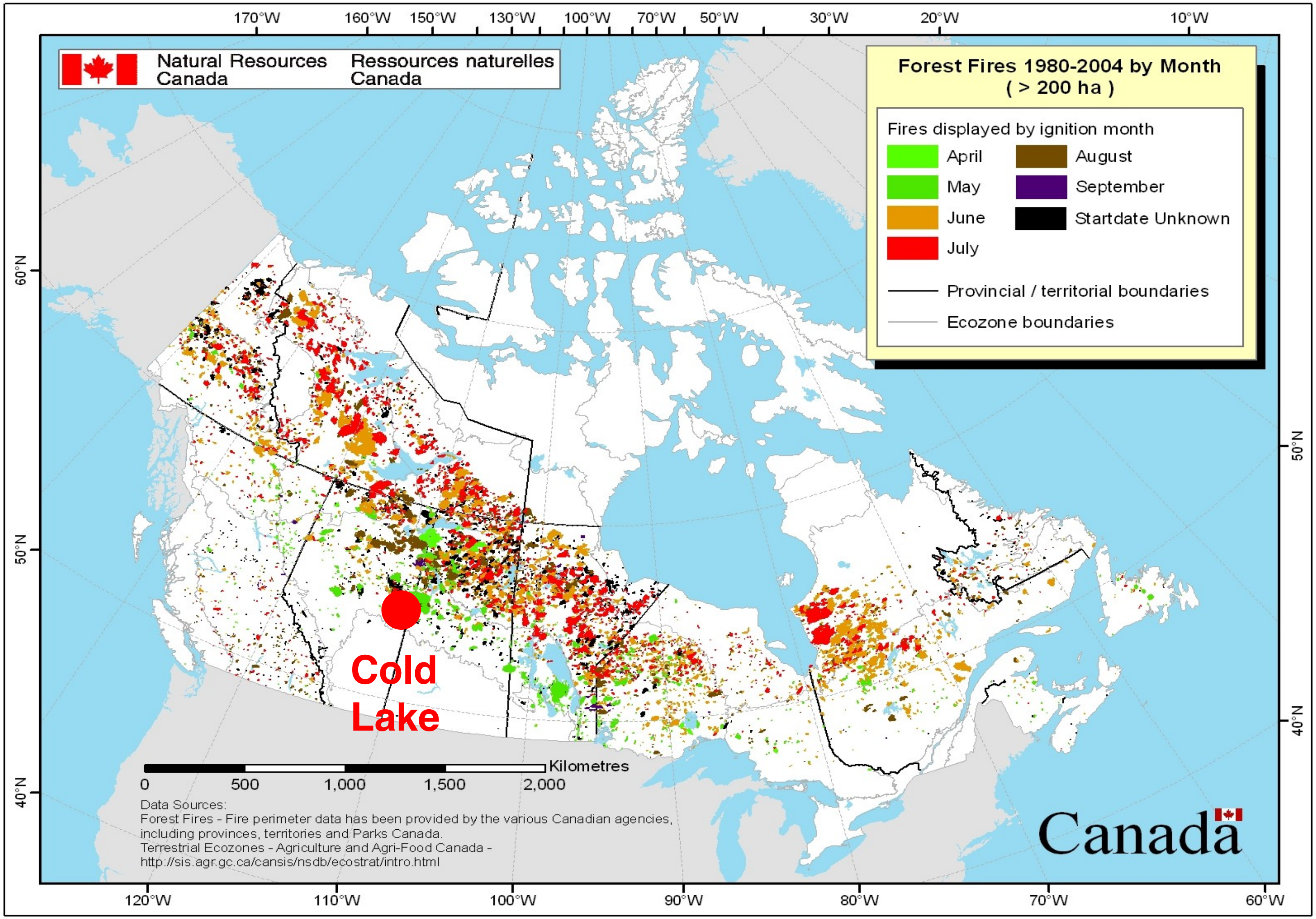
- CALIPSO aerosols
- OMI ozone, NO_2, HCHO in fire plumes
- TES CO, methane, ozone; also methanol, formic acid in fire plumes
- MLS ozone, CO, HNO_3
- MODIS, MISR aerosols
- AIRS, MOPITT CO

PRINCIPAL COLLABORATIONS:

- DLR (aircraft out of Kanger)
- NSF Summit
- Environment Canada air quality forecasts

WHY COLD LAKE, WHY JULY?

Canadian fire climatology, 1980-2004



ALBERTA TAR SANDS

Potentially large and growing emissions of methane, other VOCs…