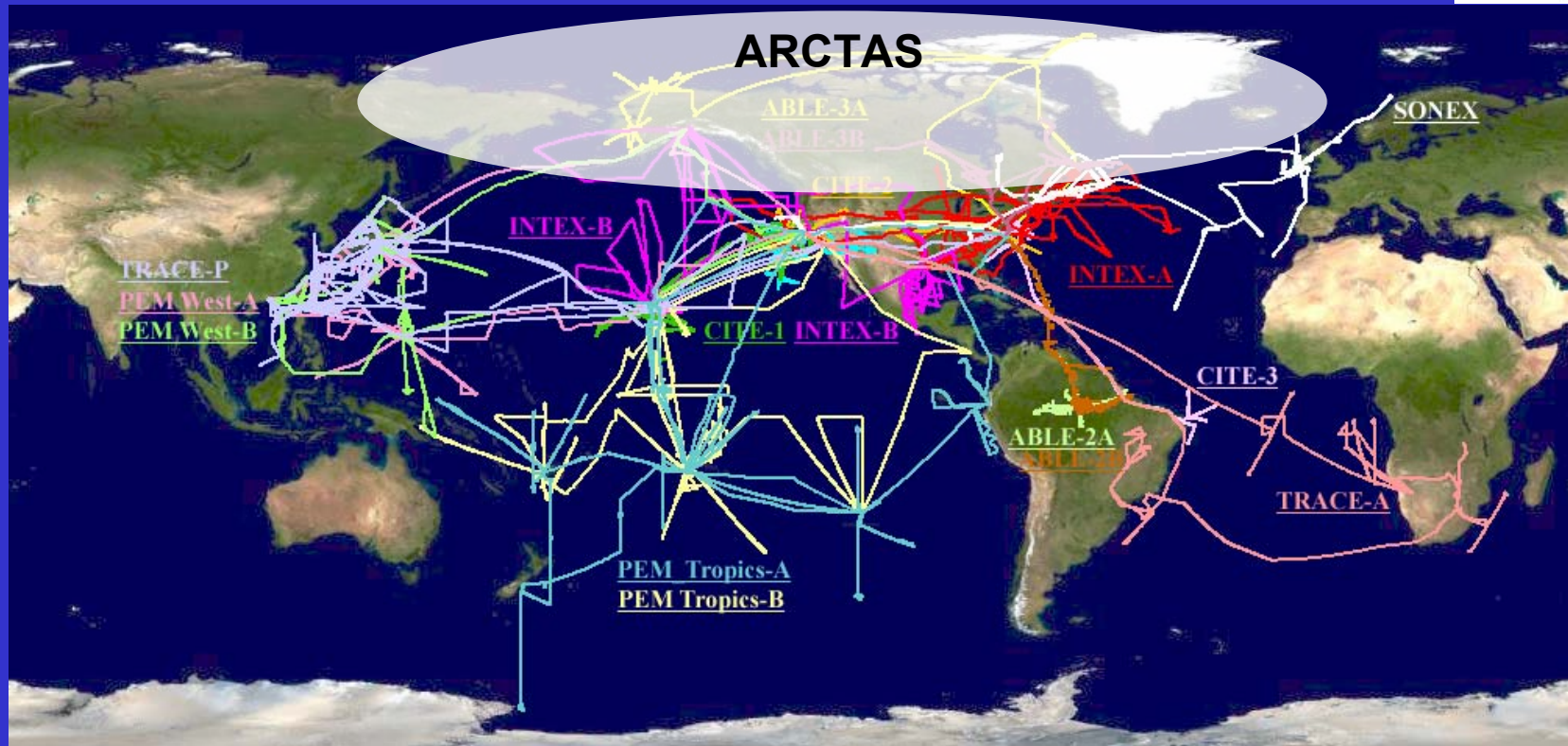


Arctic Research of the Composition of the Troposphere from Aircraft and Satellites (ARCTAS)

next planned mission of the NASA Tropospheric Chemistry Program



ARCTAS to be conducted in spring and summer 2008 (two phases) as part of the POLARCAT program during the International Polar Year (IPY)

ARCTAS white paper available: D.J. Jacob (lead), W.H. Brune, B. Cairns, K. Chance, J. H. Crawford, J. E. Dibb, J.C. Gille, R. Kahn, Q. Li, W. McMillan, B. Pierce, L.A. Remer, P.B. Russell, H.B. Singh, C.R. Trepte, J. Worden

URGENT NEED TO BETTER UNDERSTAND ARCTIC ATMOSPHERIC COMPOSITION AND CLIMATE



ARCTIC IS A BEACON OF GLOBAL CHANGE

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

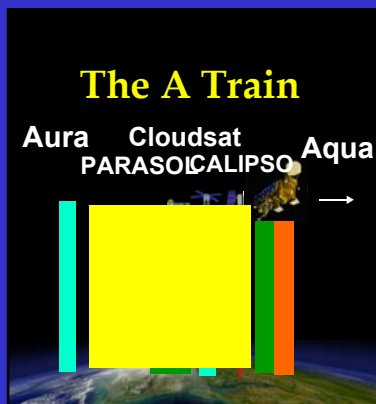


POTENTIALLY LARGE RESPONSE

- Melting of polar ice sheets and permafrost
- Decrease of snow albedo from soot deposition
- 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
- Broader synergies enabled by other IPY activities (OASIS for oceans, etc.)



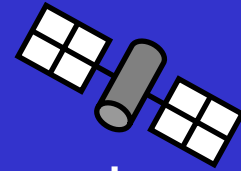
ARCTAS STRATEGY: use aircraft to increase value of satellite data for models of arctic atmospheric composition and climate

Satellites: CALIPSO, Cloudsat, OMI, TES, HIRDLS, MLS, MODIS, AIRS, MISR, MOPITT

- Aerosol optical depth, properties
- CO, ozone, BrO, NO₂, HCHO

Aircraft: DC-8, J-31, B-200

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



Retrieval algorithm development & validation
Correlative information
Model error characterization

Data assimilation
Diagnostic studies

Models: CTMs, GCMs, ESMs

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

Two 1-mo deployments: Mar-May and Jun-Jul 2008



ARCTAS Science Theme 1: winter/spring long-range transport of pollution to the Arctic

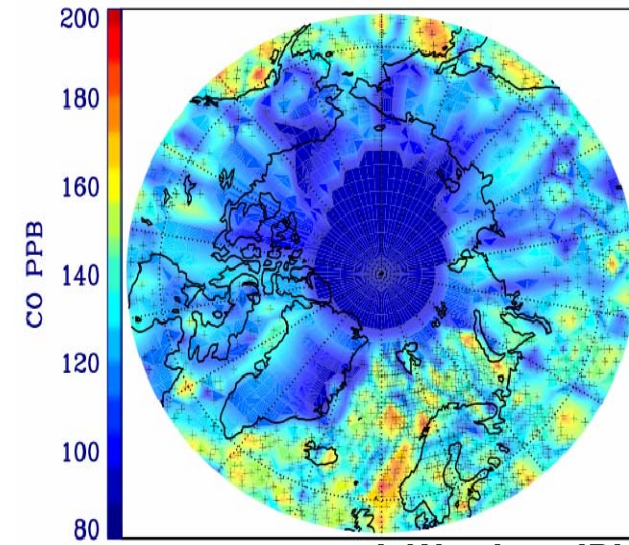
European influence



Arctic haze



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, the source-receptor relationships?
- What is the interannual variability (e.g., Arctic Oscillation)?

Satellite capabilities:

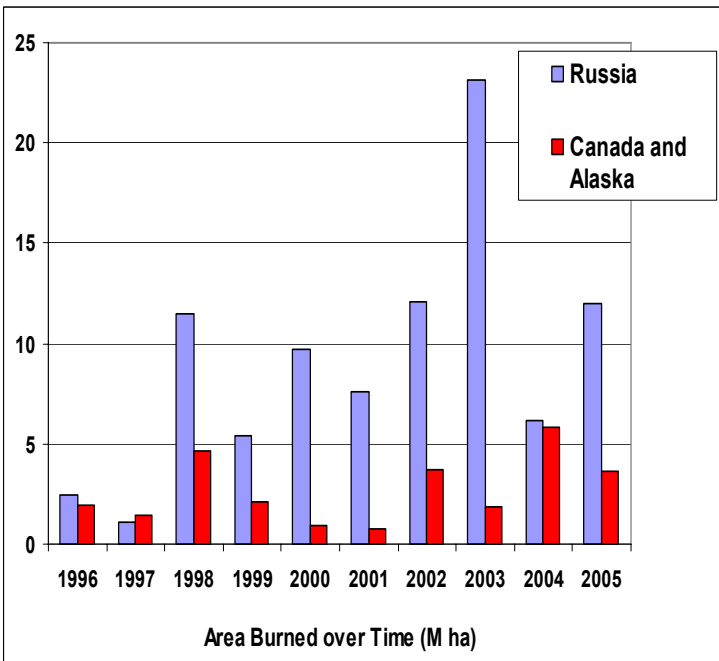
- CO (TES, AIRS, MOPITT)
- O₃ (TES, OMI-MLS)
- aerosol (CALIPSO, MODIS, MISR)

Aircraft added value:

- detailed chemical composition
- tracers of sources
- vertical information

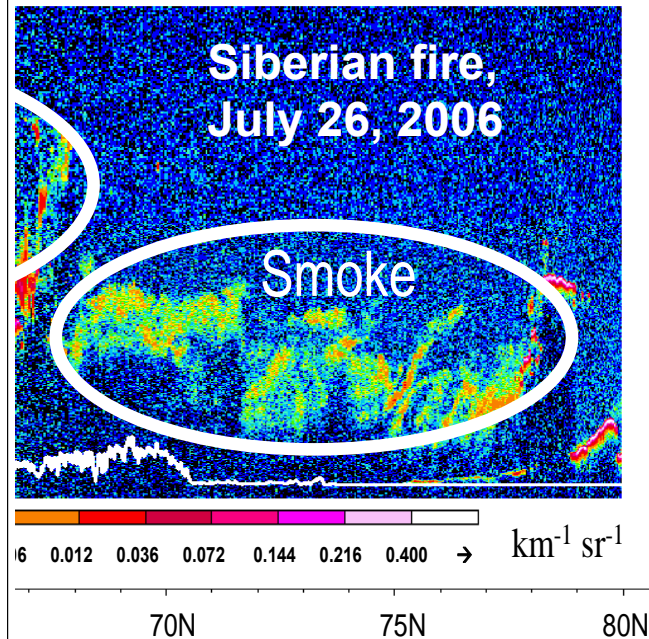
ARCTAS Science Theme 2: Boreal forest fires

Fire trend over past decade

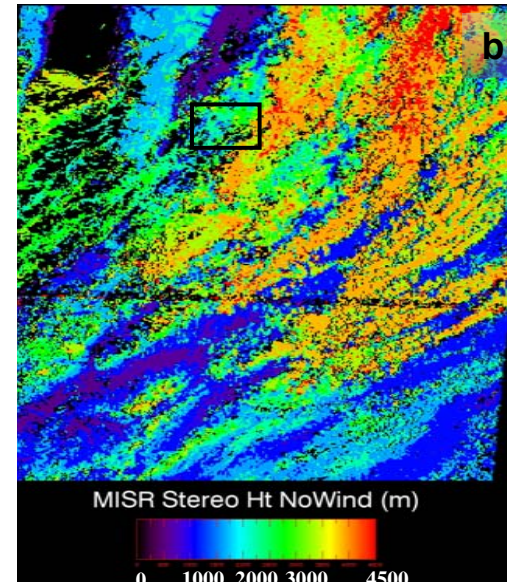


A. Soja, LaRC

CALIPSO view of fire plume MISR injection height



C. Trepte, LaRC



R. Kahn, JPL

- What is the chemical composition & 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 transport & chemistry?

Satellite capabilities:

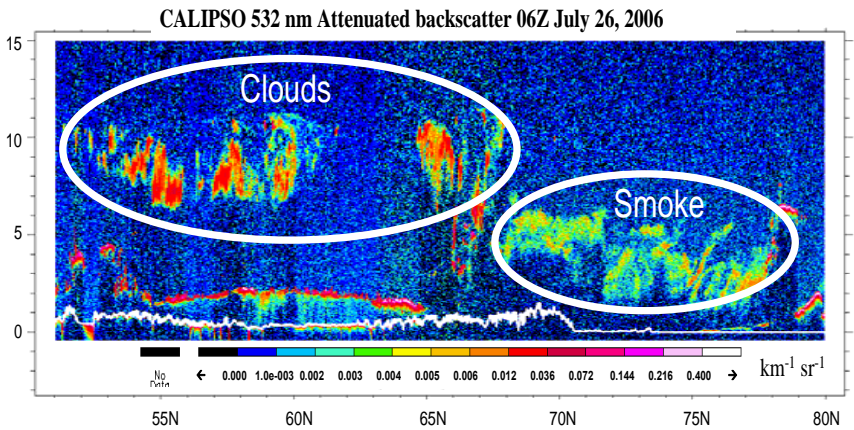
- plume layers (CALIPSO)
- injection heights (MISR)
- aerosols (OMI, MODIS, MISR)
- CO (TES, MLS, AIRS, MOPITT)

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?
- What is the effect of deposited soot on ice albedo?

Satellite capabilities:

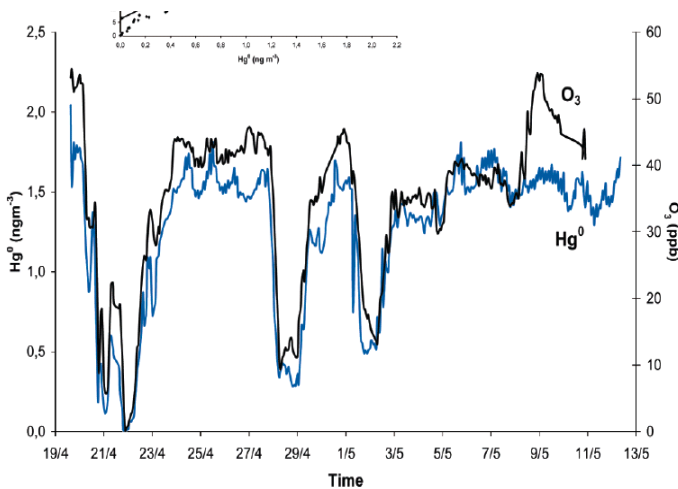
- UV/Vis/IR reflectances (Cloudsat, OMI, MODIS, MISR)
- multiangle sensing (MISR)
- lidar (CALIPSO)

Aircraft added value:

- detailed in situ aerosol characterization
- remote sensing of radiances, fluxes
- albedo and BRDF of surface

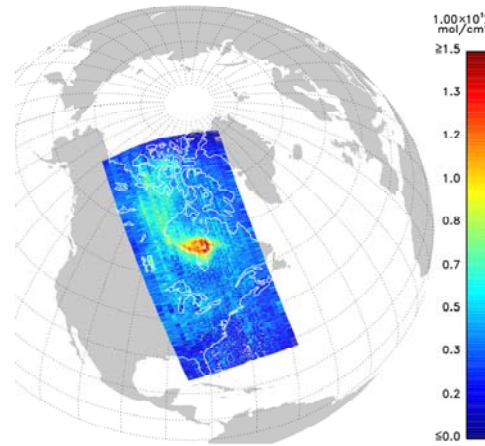
ARCTAS Science Theme 4: Chemical processes

Ozone, Hg depletion events



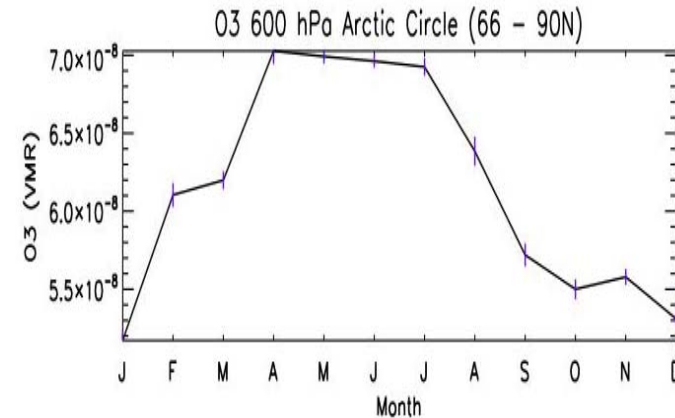
Sprovieri et al. [2005]

OMI tropospheric BrO



K. Chance, Harvard/SAO

TES tropospheric ozone



J. Worden, JPL

- What is the 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 of halogen chemistry for ozone and mercury?
- How does stratosphere-troposphere exchange affect tropospheric ozone in the Arctic?

Satellite capabilities:

- Ozone (TES, OMI/MLS)
- BrO (IOMI)
- 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: major in situ platform

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 , halogen reservoirs, mercury, NMVOCs, halocarbons, SO_2 , HCN/CH_3CN , actinic fluxes, aerosol mass and number concentrations, aerosol physical and optical properties, remote ozone and aerosol



J-31: major aerosol remote sensing platform

Ceiling 26 kft, range 800 nmi, endurance 5 h

Payload: optical depth, radiative flux, radiance spectra



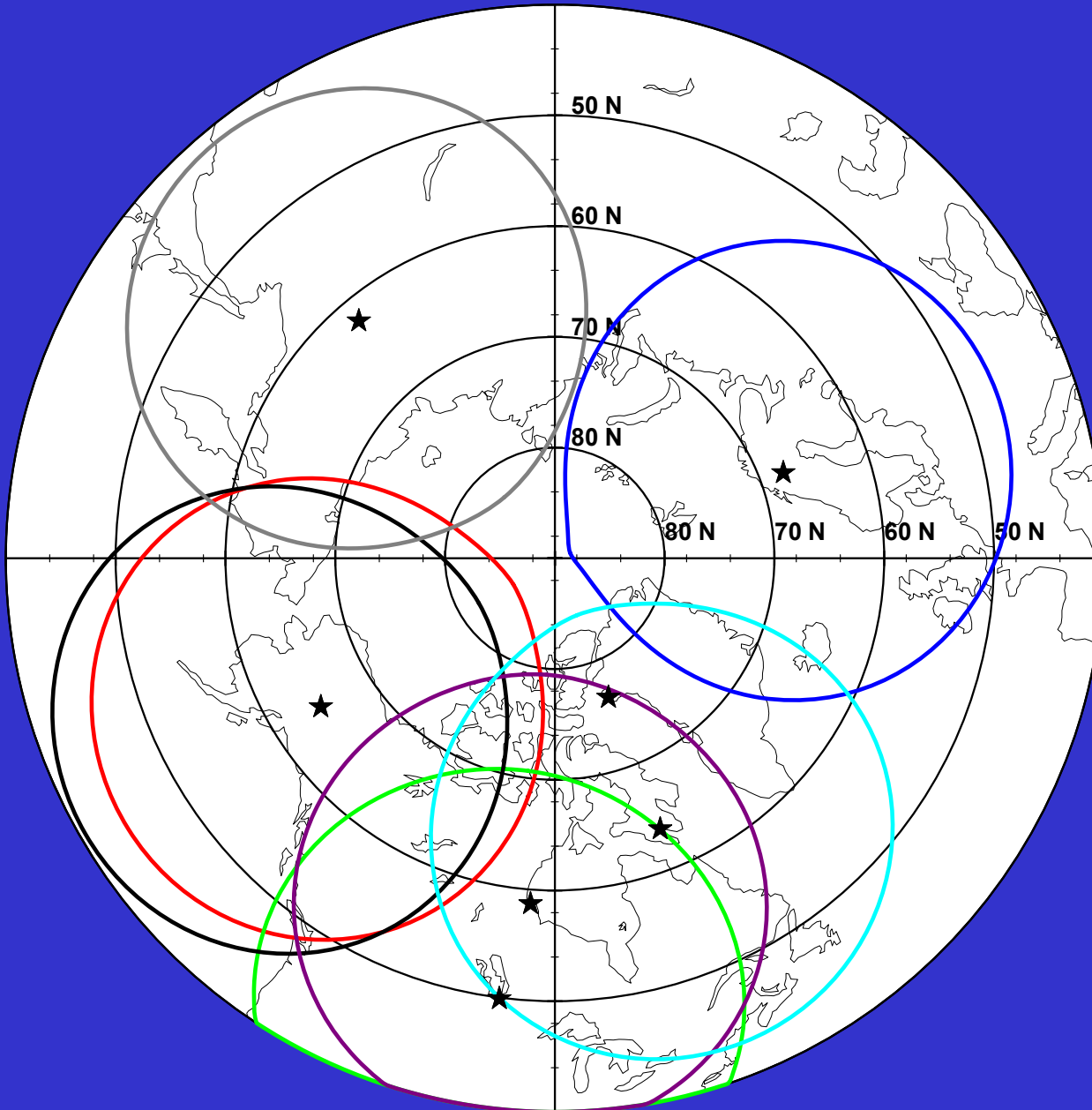
B-200: major CALIPSO validation platform

Ceiling 32 kft, range 800 nmi, endurance 3.5 h

Payload: High Spectral Resolution Lidar (HSRL)



POTENTIAL ARCTAS BASES AND NOMINAL DC-8 RANGES

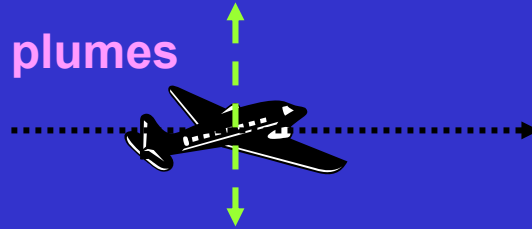


- Anchorage**
- Fairbanks**
- Churchill**
- Winnipeg**
- Kiruna (spring)**
- Iqaluit**
- Thule**
- Yakutsk**

DC-8 FLIGHT STRATEGIES

Lidar remote sensing:

- mapping of pollution plumes
- satellite validation



Process studies:

- photochemistry
- plume evolution
- transport mechanisms



Satellite validation



Characterization of emissions, surface uptake

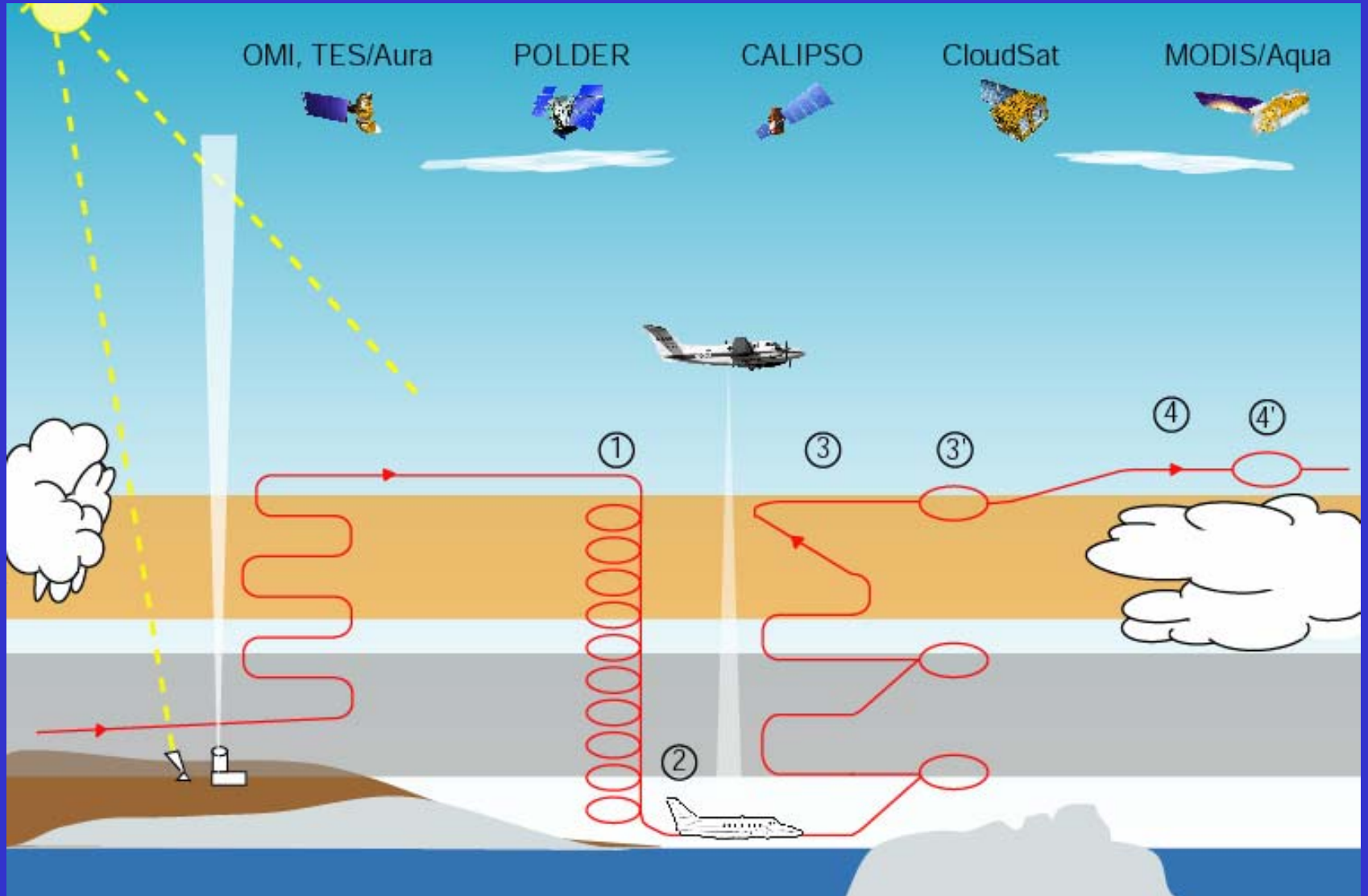


Air mass characterization

- global and regional chemical budgets
- long-range transport



J-31 FLIGHT STRATEGIES



MAJOR INTERAGENCY AND INTERNATIONAL PARTNERSHIPS UNDER POLARCAT

- **NSF/OPP+ATM: summer surface chemistry intensive at Summit**
- **DOE: aircraft intensive at Alaska ARM site in April 08, focus on aerosol-cloud radiation**
- **NOAA (not committed yet): WP-3 based in Iqaluit and R/V Brown cruise to Greenland and Barents Seas, focus on aerosol-cloud interactions and North American export of pollution**
- **DLR (likely, not committed yet): Falcon based in NE Canada in summer 08, focus on pyroconvection and cirrus chemistry**
- **Canada (pending): three aircraft in summer 07 and 08 based in Yellowknife, focus on pyroconvection.**