Global Fire Emissions and Fire Effects on Biophysical Properties and the Associated Radiative Forcing

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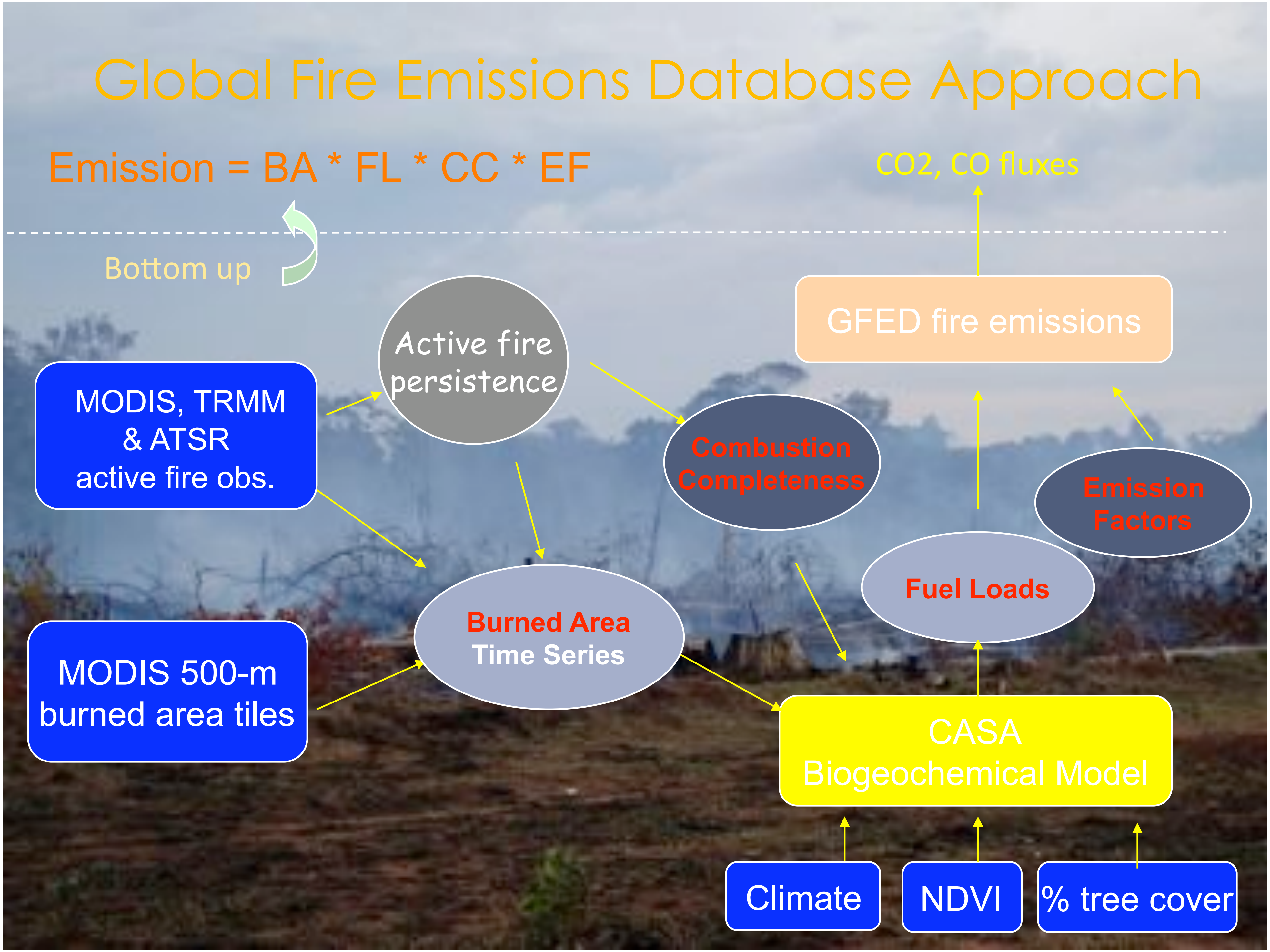
Global Fire Emissions Database (GFED)

- Quantify fire emissions for large scale modeling studies in atmospheric chemistry and fire-climate feedback

  - using MODIS land products from 2001 onward

  - extended back to 1997 with TRMM and ATSR active fires and AVHRR vegetation index

- Refined and updated in the past 5 years
- Data archived at ORNL (v1, v2, v2.1)
- GFED v3 will be available in 2~3 months


Global Fire Emissions Database Approach
Emission = BA * FL * CC * EF
CO2, CO fluxes
Bottom up
Active fire persistence
GFED fire emissions
MODIS, TRMM & ATSR active fire obs.
Combustion Completeness
Emission Factors
Fuel Loads
Burned Area Time Series
MODIS 500-m burned area tiles
CASA Biogeochemical Model
Climate
NDVI
% tree cover

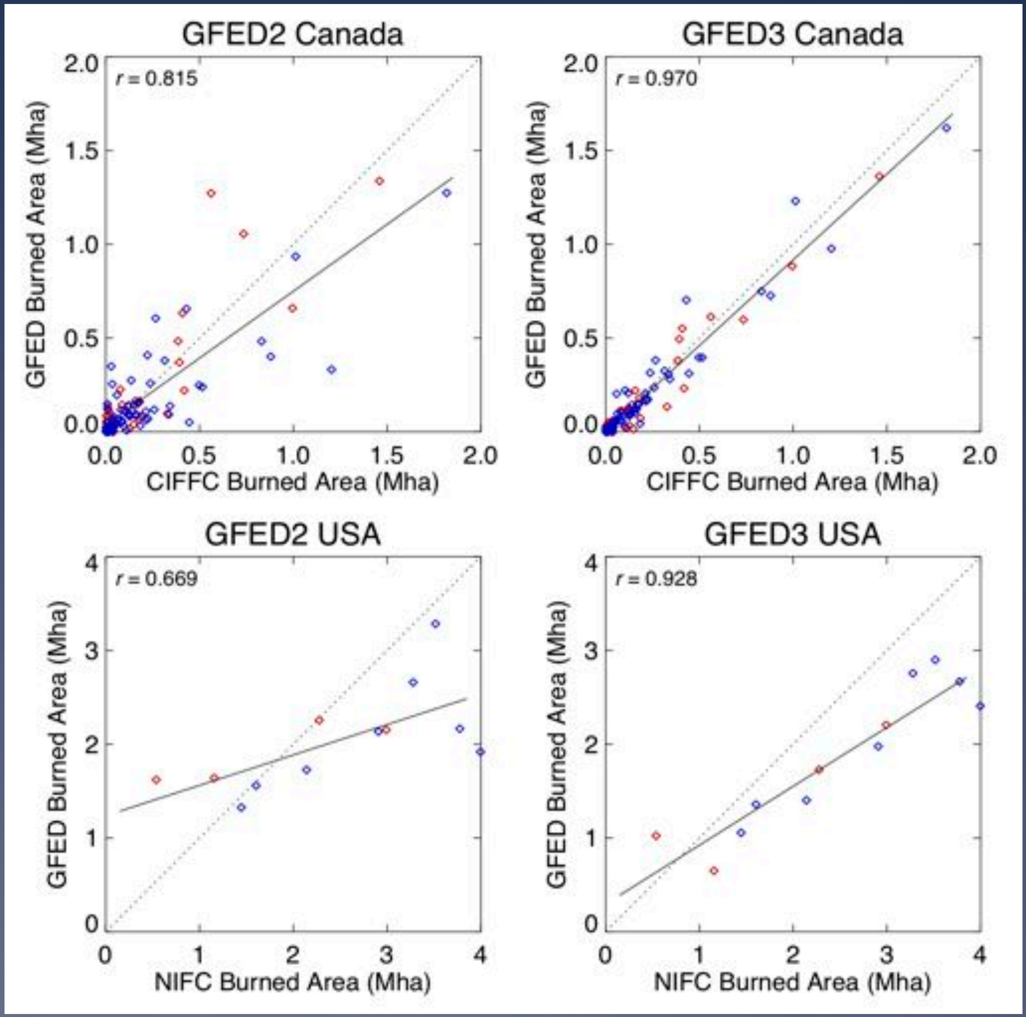
Improvements

- New burned area approach – using many more 500m observations (Giglio et al. 2010)
- Improved fPAR dataset from Jim Collatz - merging GIMMS and MODIS for 1983-present
- Emission factors derived using land cover type and active fire observations at 1km
- Higher spatial resolution (0.5° X 0.5°)
- 8 day, 3-hourly emissions using MODIS active fire and GOES daily ABBA active fire (under development)
- Better soil moisture estimate with new ET algorithm with MODIS net radiation and LAI

Global burned area

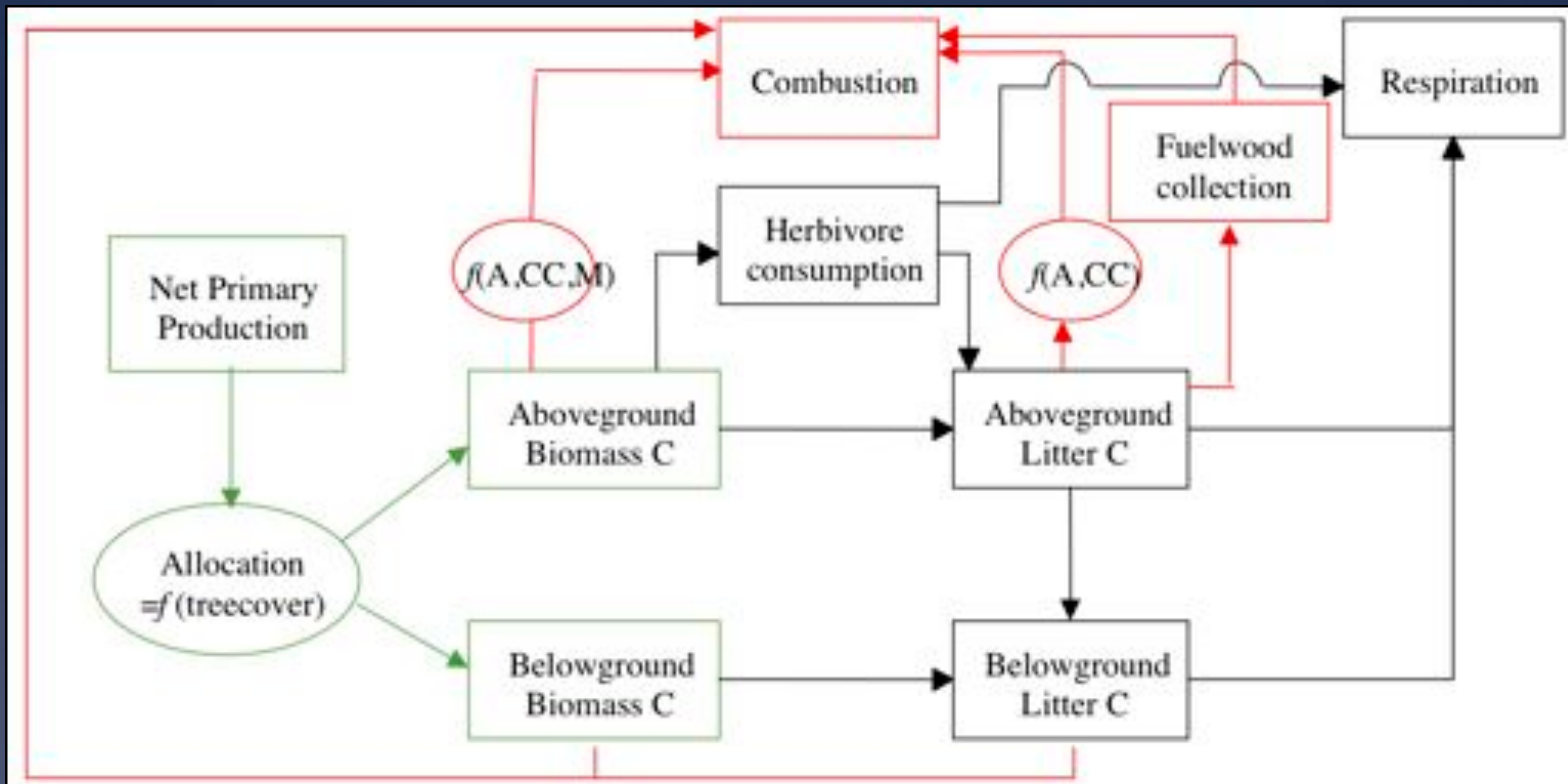
- Where available, we use 500-m burned area maps produced by a change detection algorithm with MODIS surface reflectance (Giglio et al, 2010)

- Burned area extended to other periods and area by relating this burned area product in each region to active fire detections from MODIS, TRMM/VIRS, and ATSR instruments



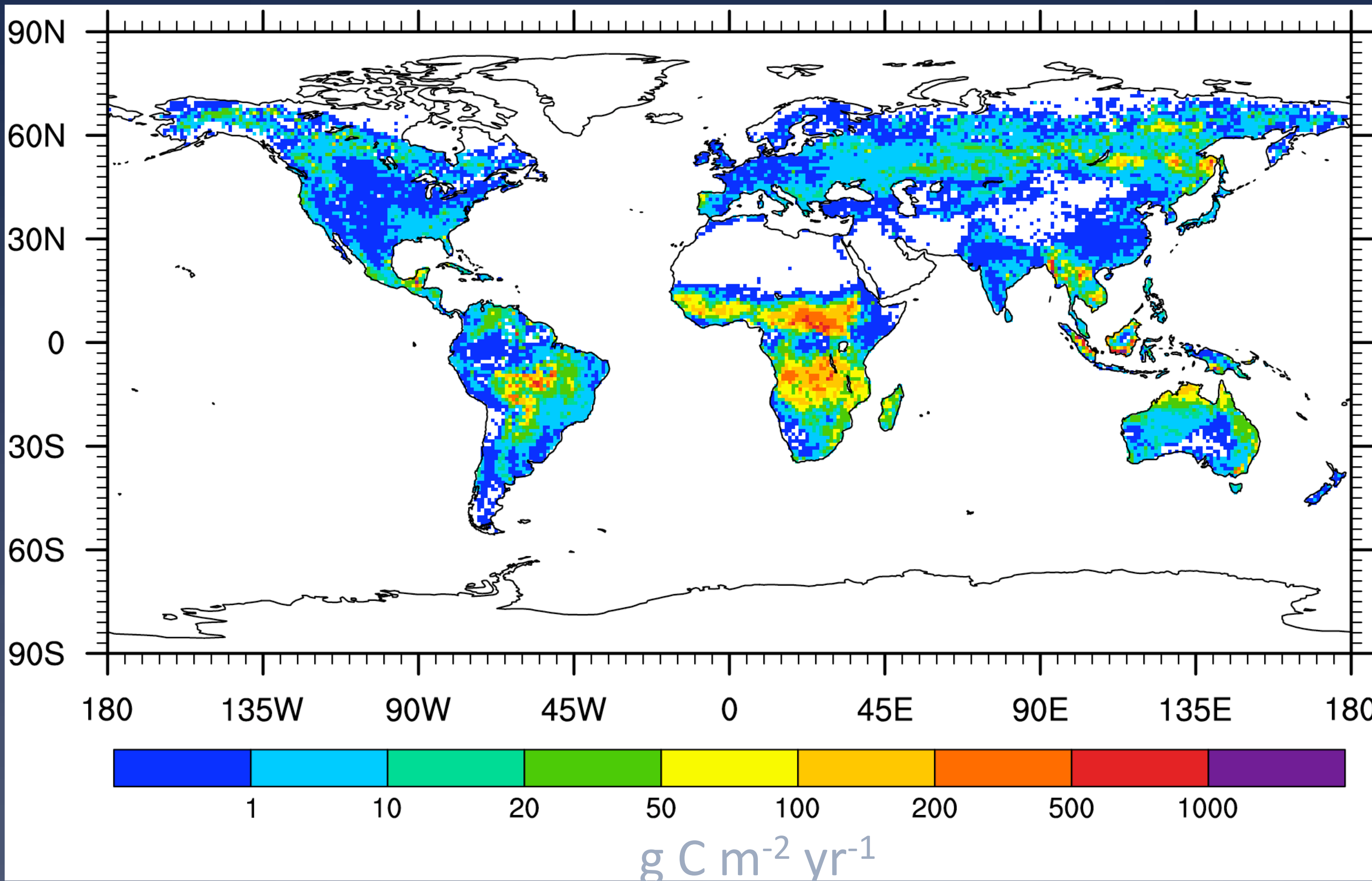
blue: MODIS era (2001-2008)
red: Pre-MODIS era (1997-2000)

Fuel loads estimated from CASA



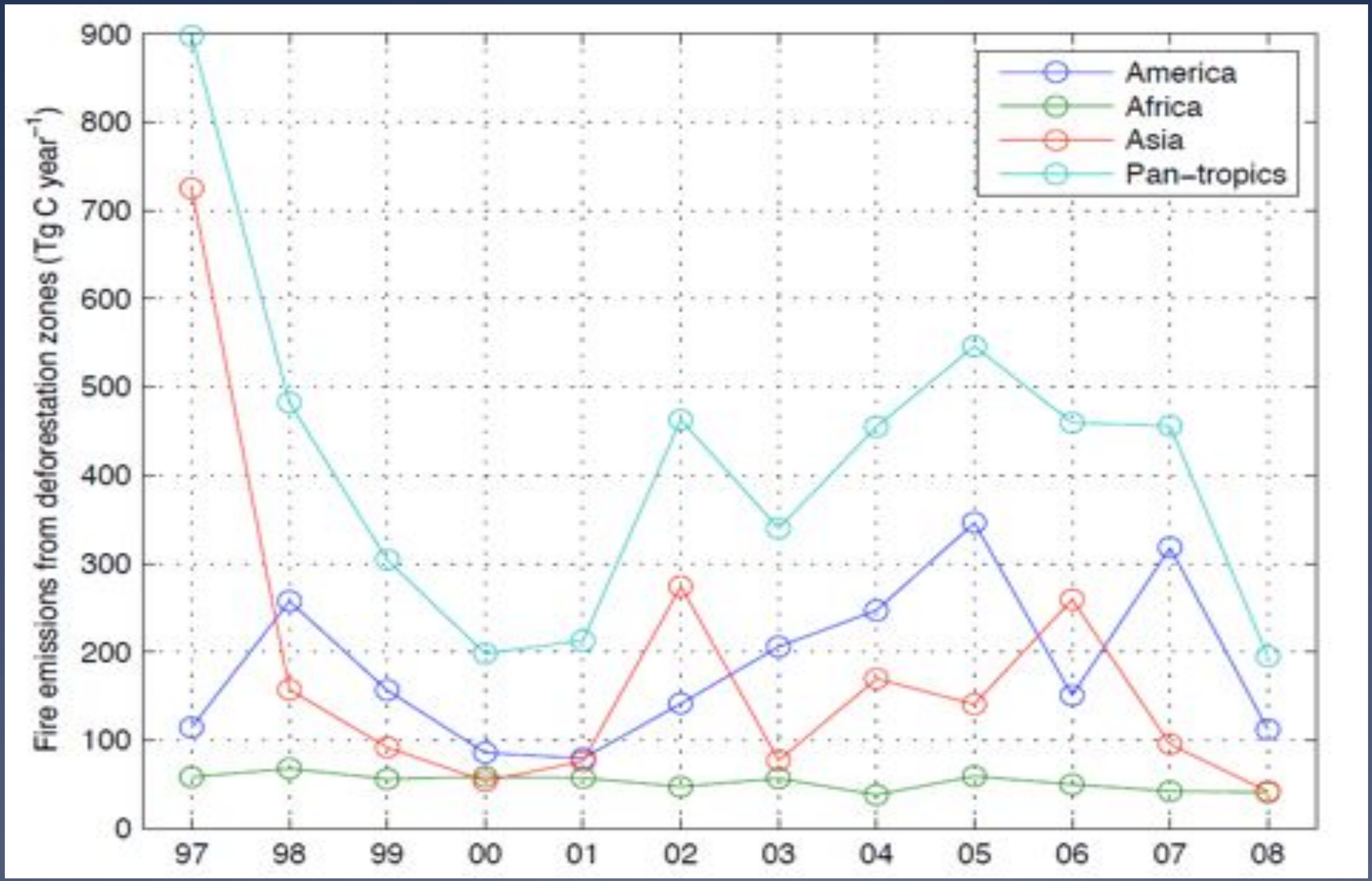
- Driven by satellite observations
- Includes a representation of peat and organic soil burning
- Allocation optimized to match tropical aboveground biomass inventories (Saatchi et al., 2007)

Annual mean fire emissions 1997-2008



- Global fire emissions: ~2.3 Pg C/yr
- ~ 1/4 of total occurs at the deforestation frontier

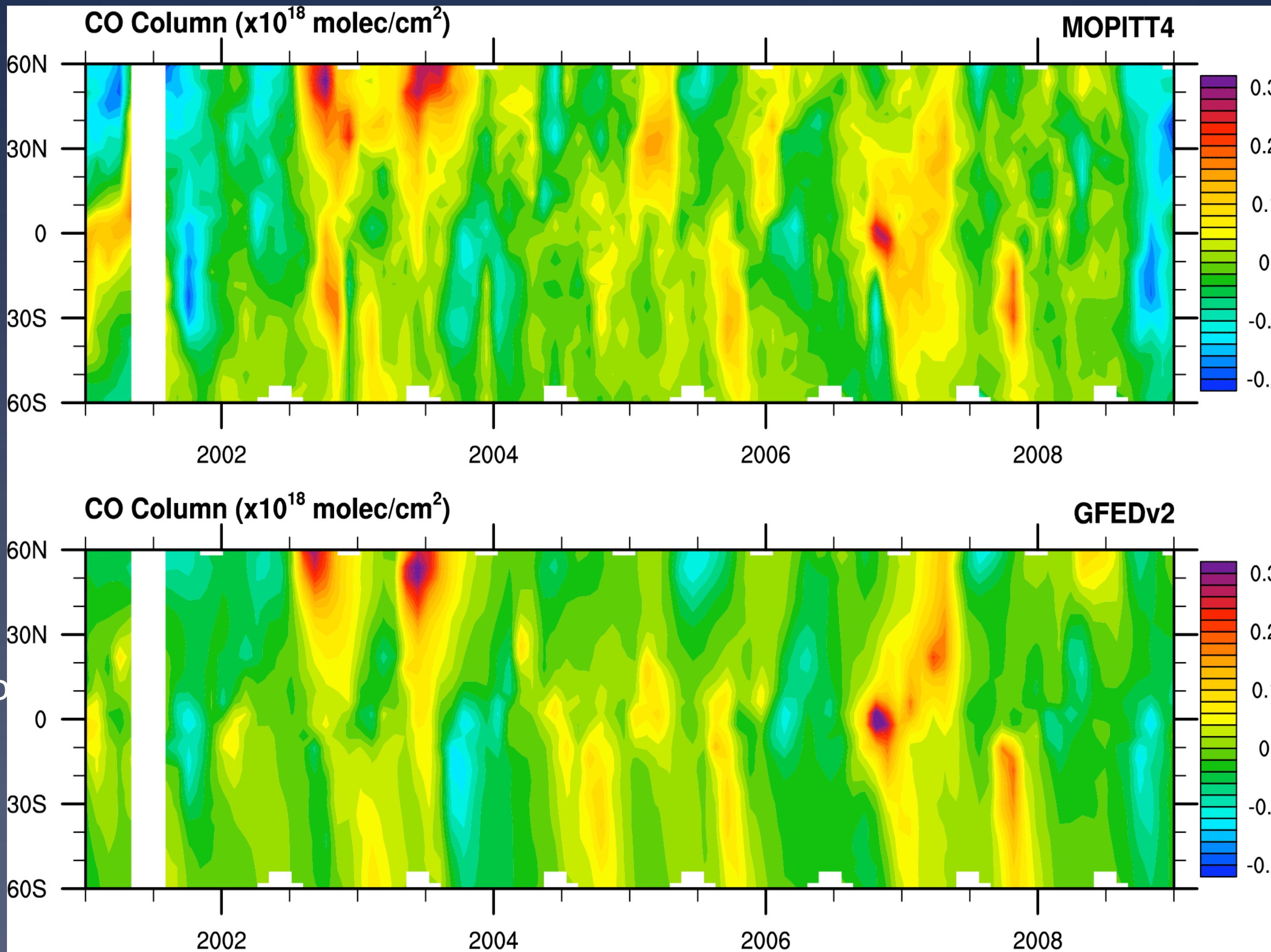
Fires at the deforestation frontier are highly variable from one year to the next



CO column comparisons with MOPITT

Observed Anomalies from MOPPIT

Fire contributio from GFED and GEOS-CHEM

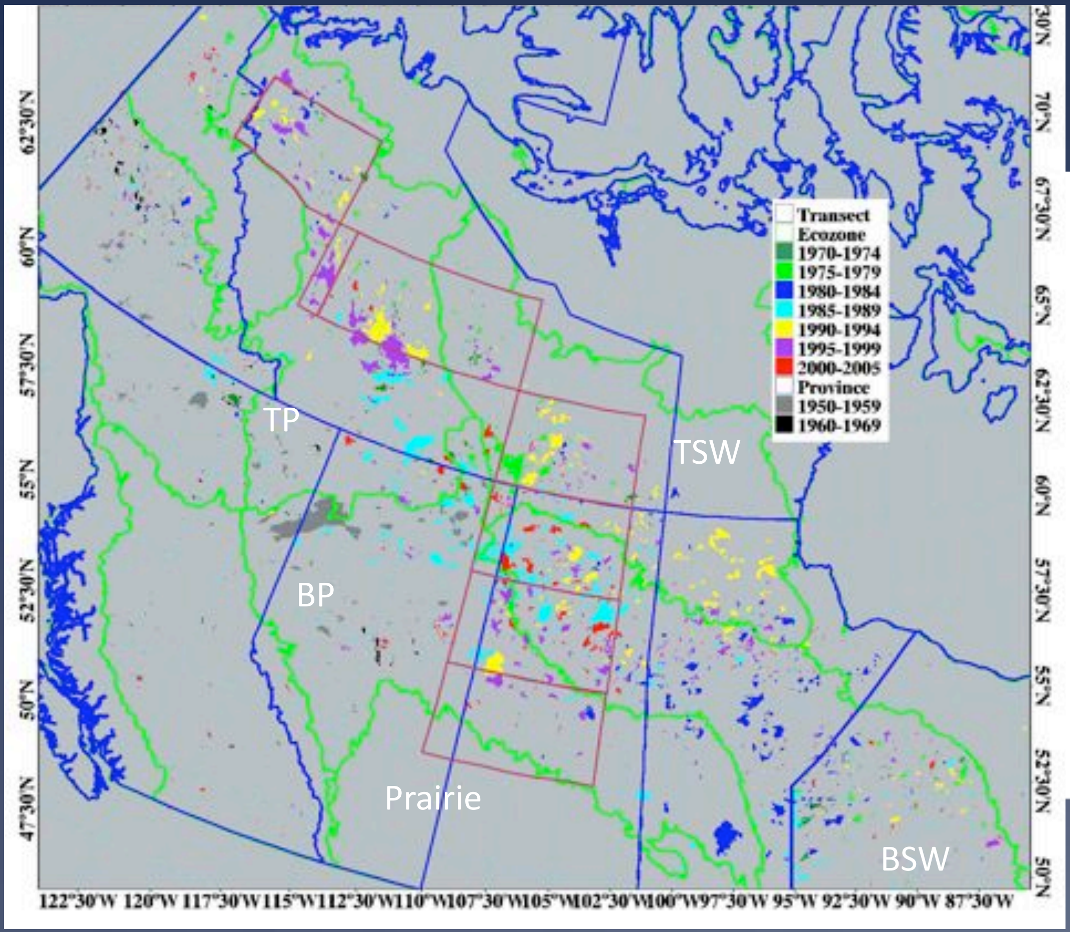


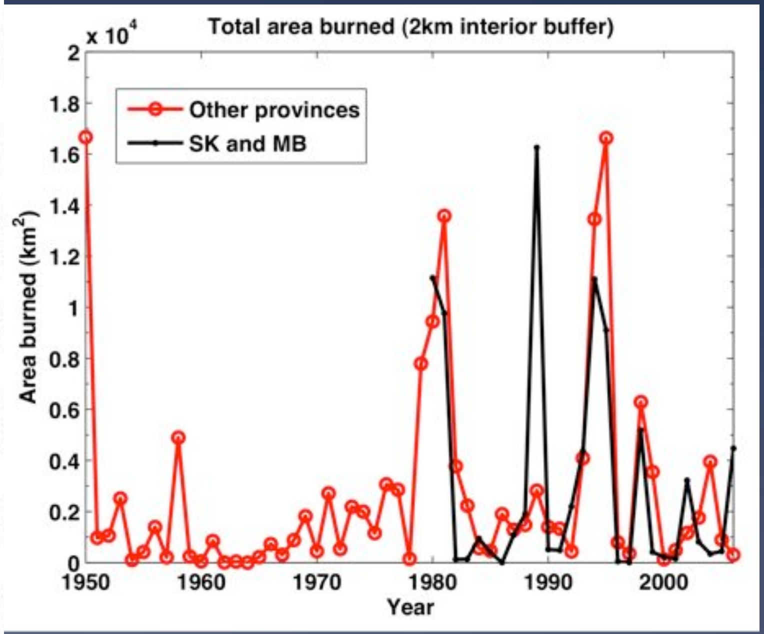
MOPITT - Measurements of Pollution in The Troposphere

Fire effects on surface albedo and LST and the associated radiative forcing

Spatial/temporal distribution of large fires

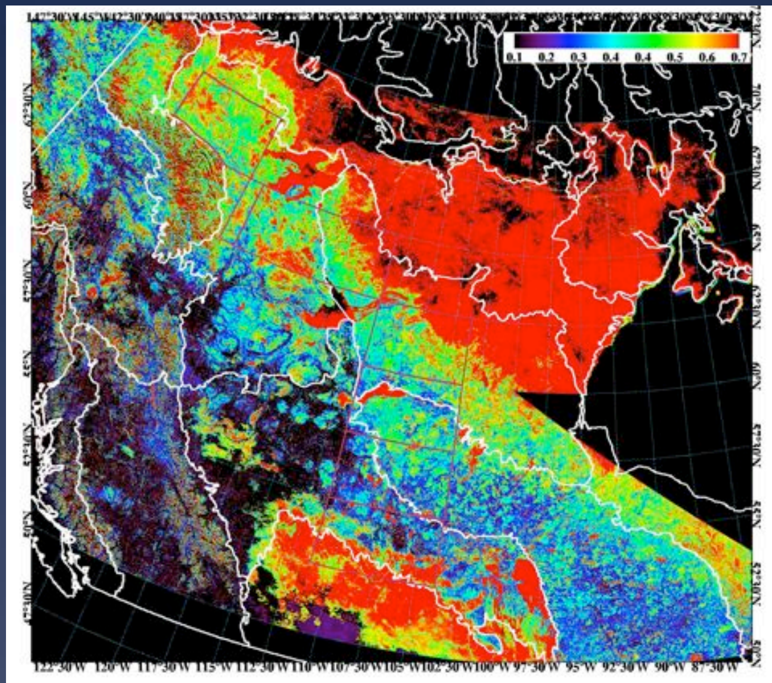
Canada: 1950 ~ 2006

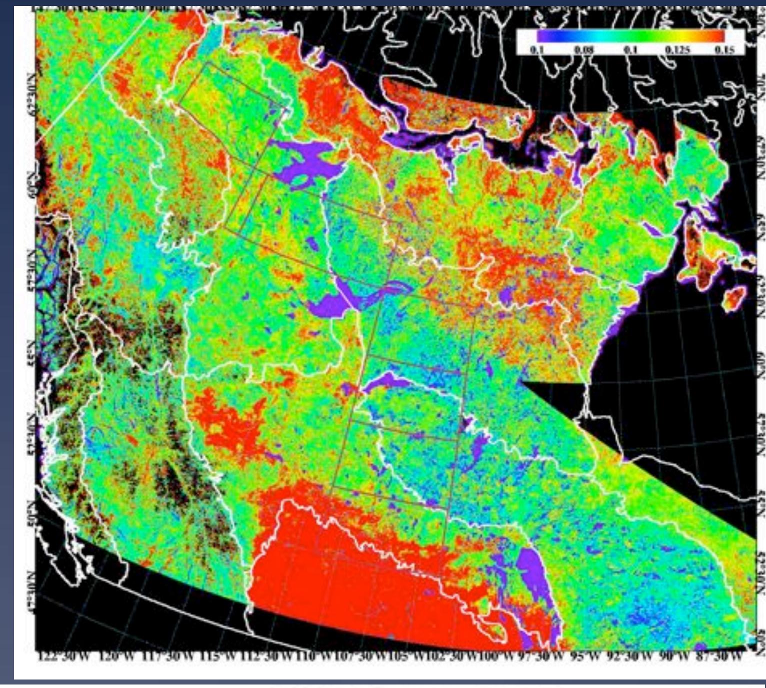


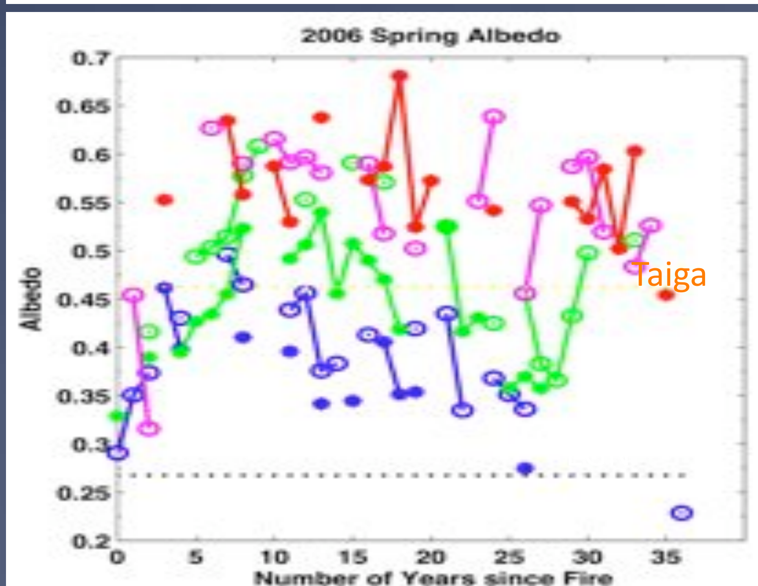


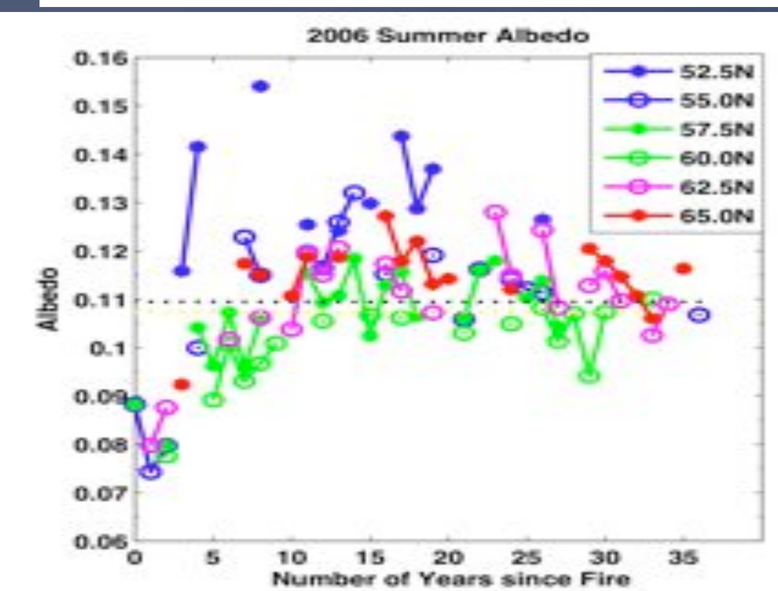
- Fire is a dominant disturbance agent for boreal forests
- Concentrated in Boreal and Taiga ecozones
- Large interannual variablity

2006 spring and summer albedo

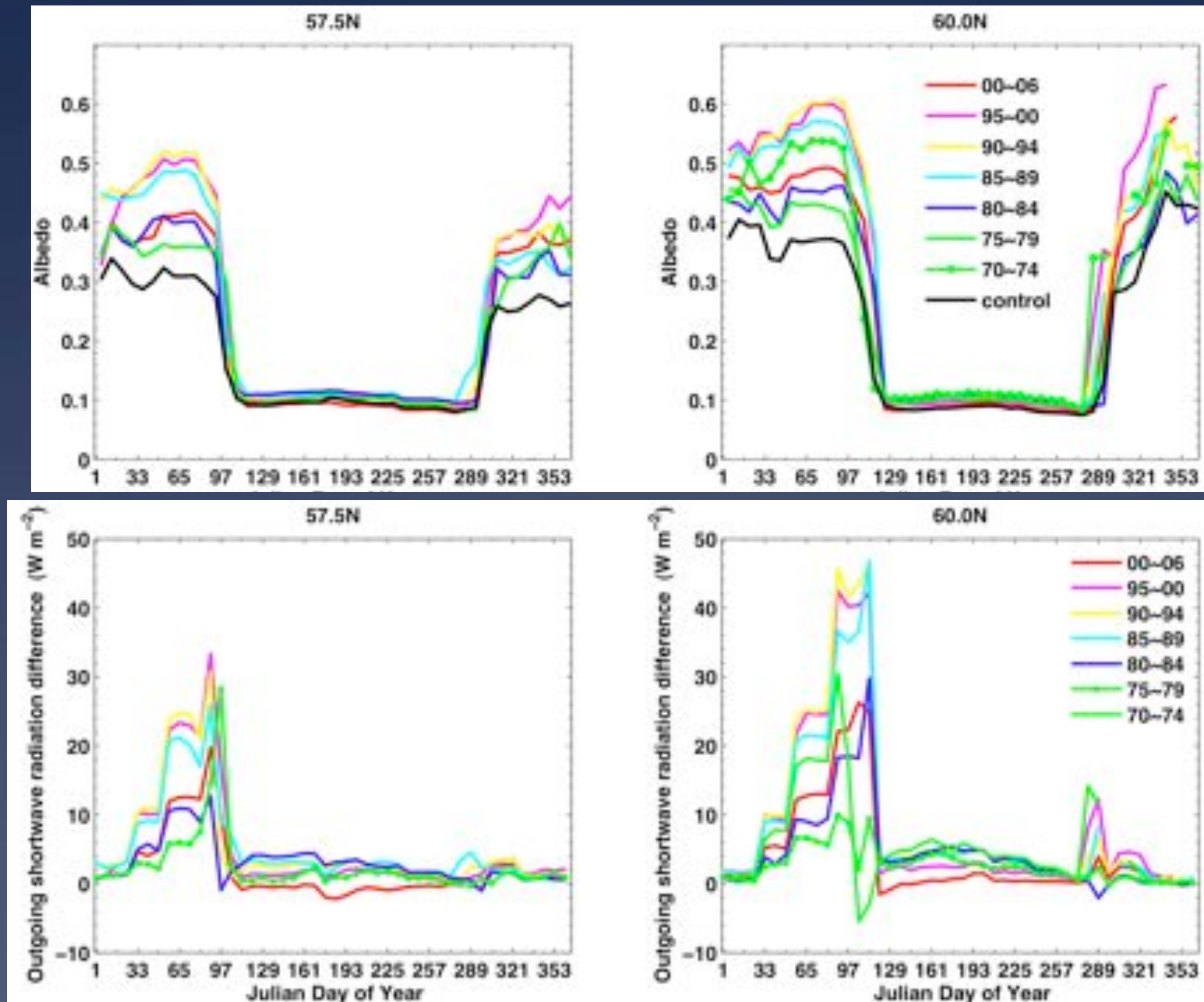








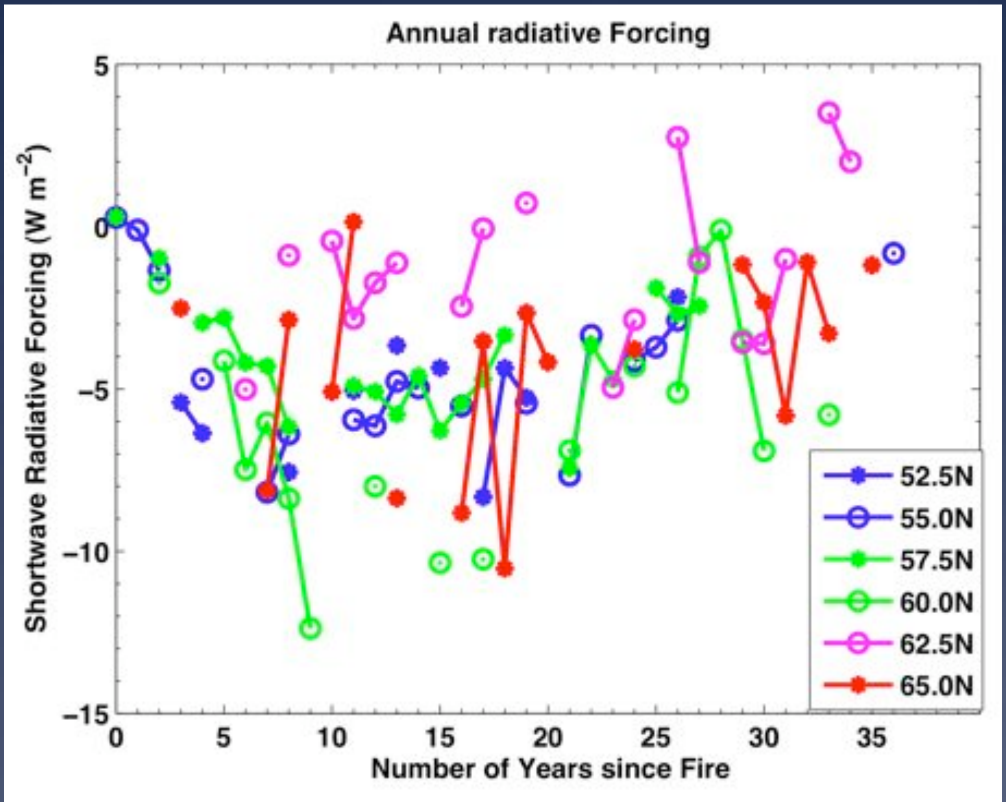
Seasonality of albedo and SW radiative forcing



- **Late spring controls magnitude of forcing:**
  trade-off between albedo change and incoming solar
- **Snow melting later after fire in forest zone: larger negative forcing**

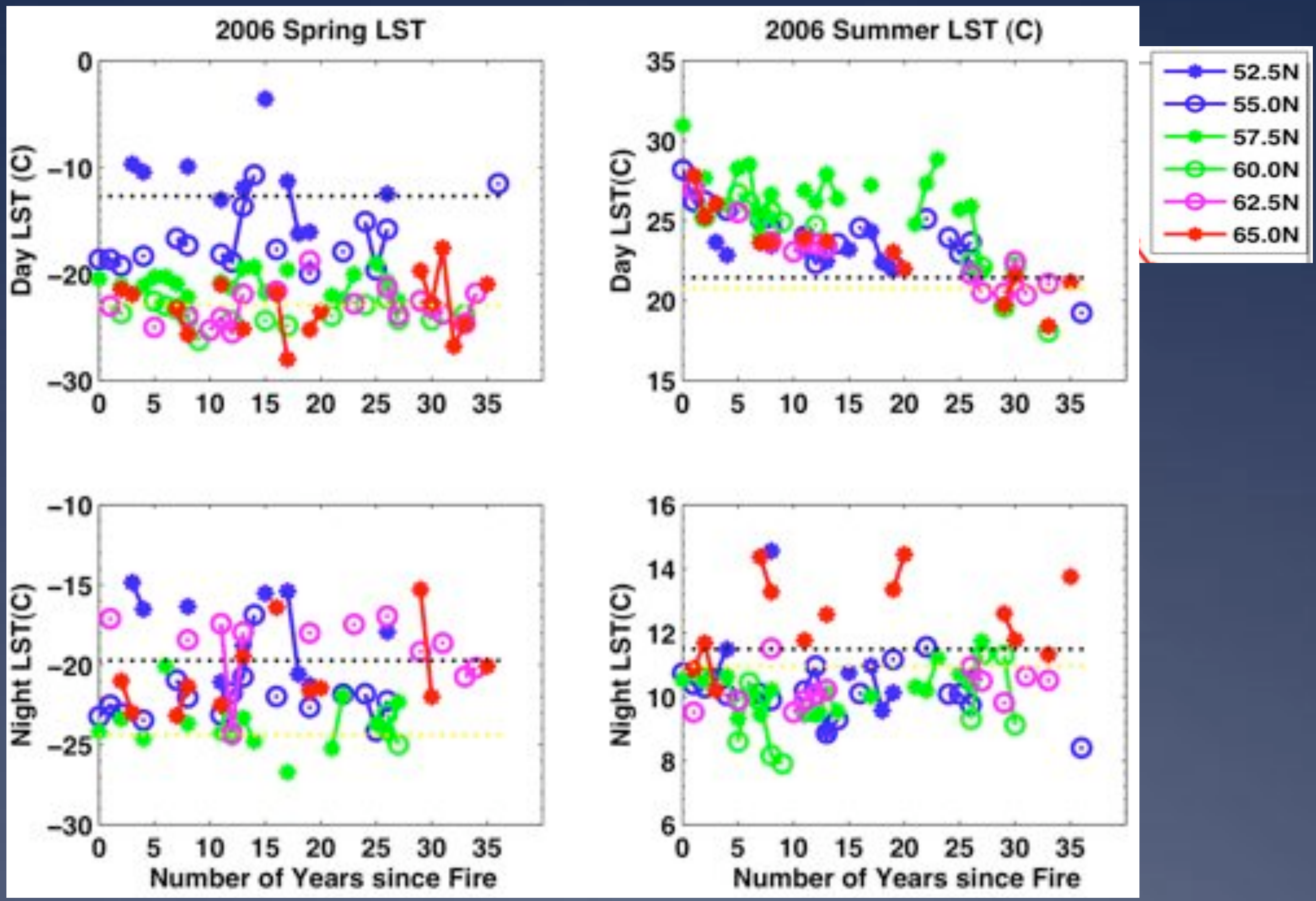
Shortwave radiative forcing

$$RF^{sw} = -(\alpha - \alpha_0) \cdot S^{\downarrow}$$



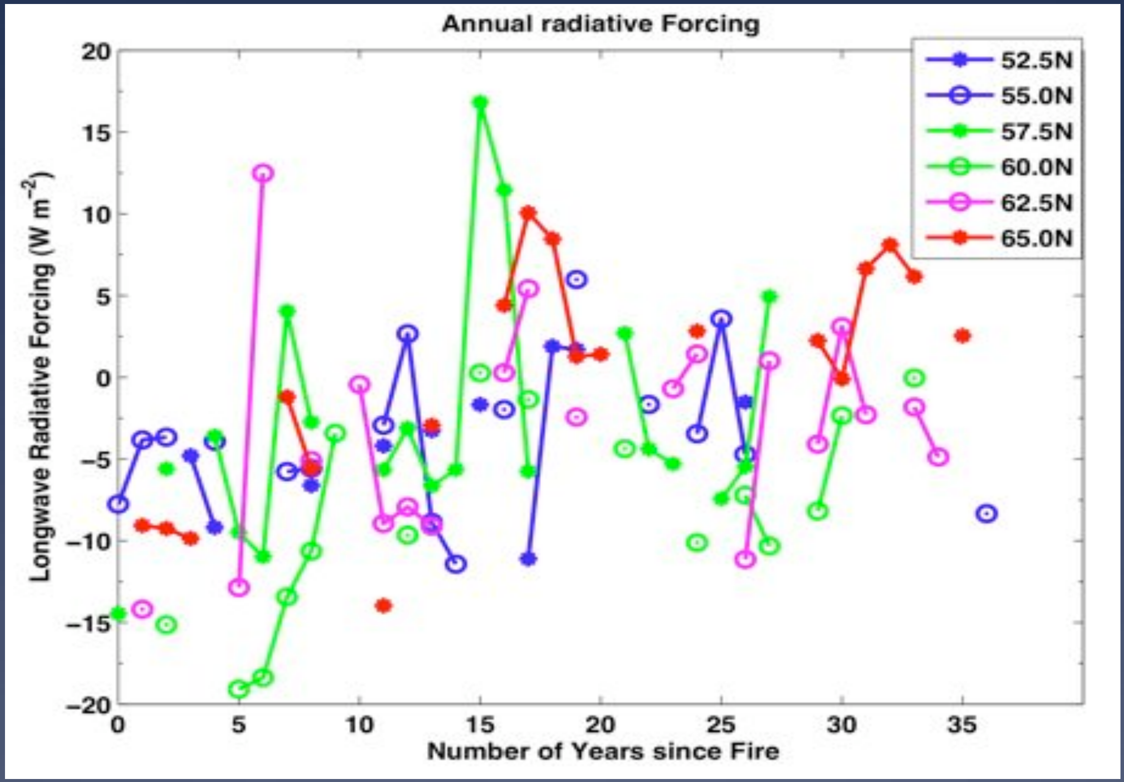
- Magnitude of SWRF increases with stand age, peaks around 15-25 years
- Weak increasing trend in forests from South to North
- SWRF smaller in Taiga zones than forests due to smaller albedo difference in early spring and earlier snow melting in late spring

Fire effects on land surface temperature



- **Day time temperature: increase in summer vs. decrease in winter**
- **Postfire day temperature change decreases with stand age in summer**
- **Night time temperature: decrease in summer**

Annual longwave radiative forcing



- Negative LWRF in general, except in Taiga (mid- to late succession)
- Magnitude of LWRF decreases with stand age
- Magnitude of LWRF increases from south to north in forested area
- Taiga/tundra has less negative LWRF

Concluding Remarks

- GFED provides a consistent record of large scale fire emissions since 1997 and captures the interannual variation in fire emissions.
- Improvements are under development to reduce uncertainties.
- GFED v3 will be available in ORNL in 2~3 months.
- Fire reduces both annual net shortwave (dominated by spring albedo increase) and longwave radiation (dominated by summer surface temperature increase).
- The magnitude of SW and LW RF is similar (-2 ~ -6 W m^{-2}) in Canadian boreal forests.