Ecosystem and atmosphere modelling in EC/CRD

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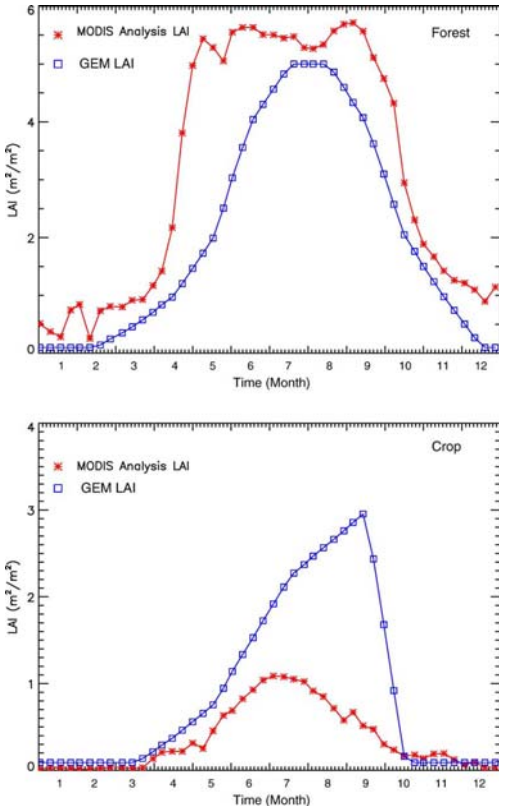
Outline

- Ecosystem model for GEM
  - Biome-BGC
  - Time dependent vegetation characteristics, e.g. LAI (climatological in GEM)
  - Flux (NEE) over Canada for carbon cycle research
- Concentration modelling in GEM
  - Synoptic features in concentration field
  - Comparison to continuous concentration measurements of CO_2 and CH_4 (signals from ecosystem and anthropogenic sources)

GEM LAI & MODIS



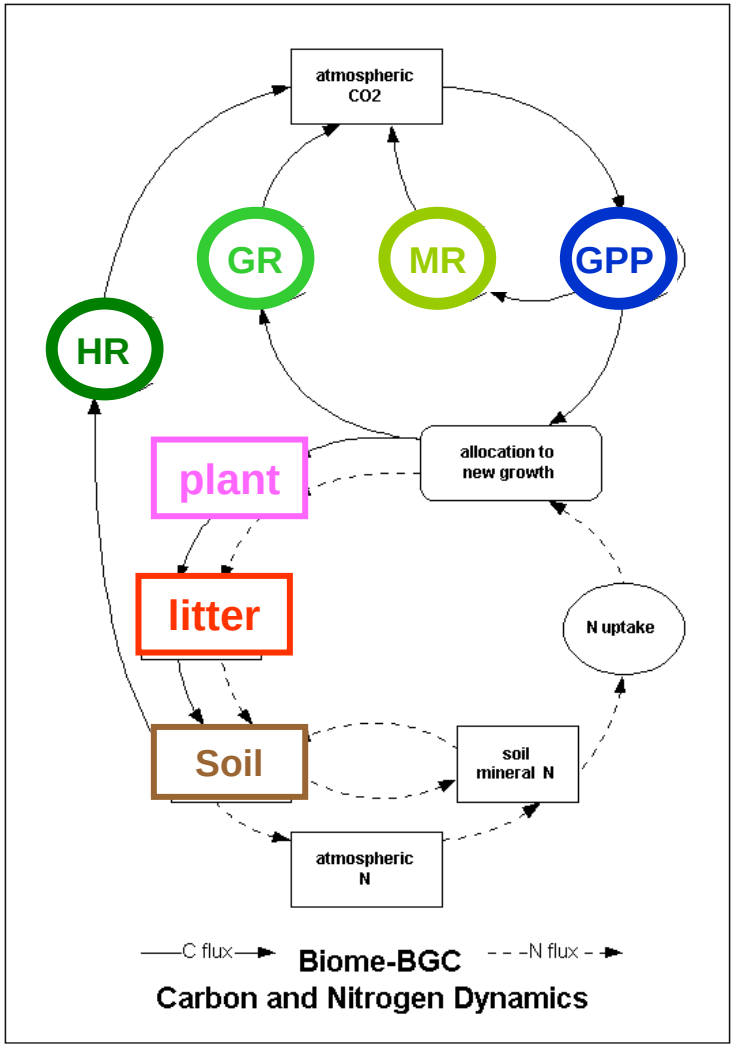
(from Gu et al. 2006)

MODIS LAI smoothed
Useful to have modelled LAI to assimilate MODIS LAI

Biome-BGC

Carbon Fluxes and Storages

LAI is a part of vegetation carbon (plant).



C flux

N flux

Photosynthesis (**GPP**)

Maintenance **R**espiration

Growth **R**espiration

Heterotrophic **R**espiration

Spin-up (GEM forcing)

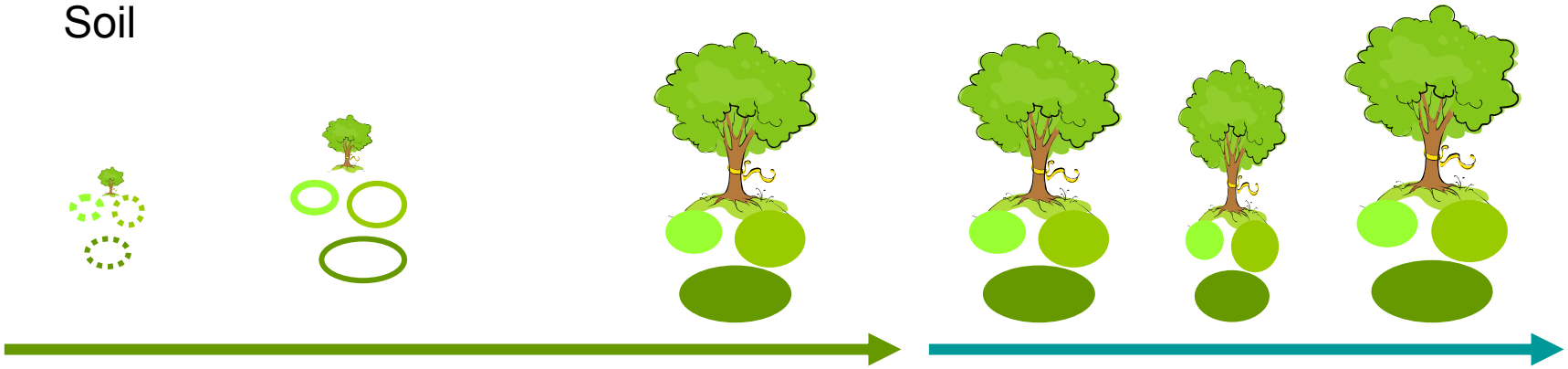
Biome-BGC needs Spin-up before normal run

Spin-up

Build-up of Organic Carbons in Vegetation and Soil

Normal Run

Time Evolution of carbon content and carbon flux



~500 to ~5000 years

1 to ~10 years

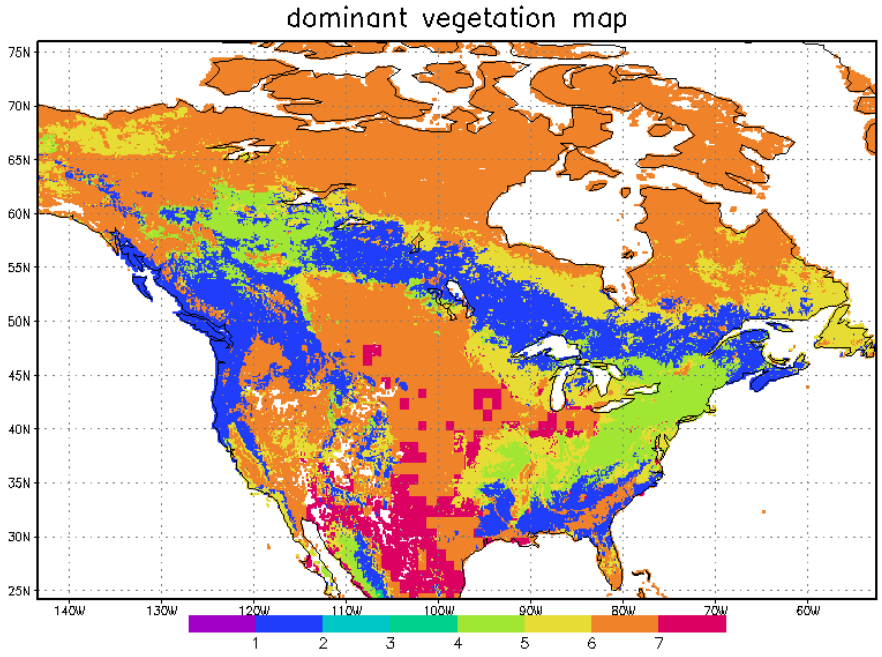
Daily BGC

Hourly BGC

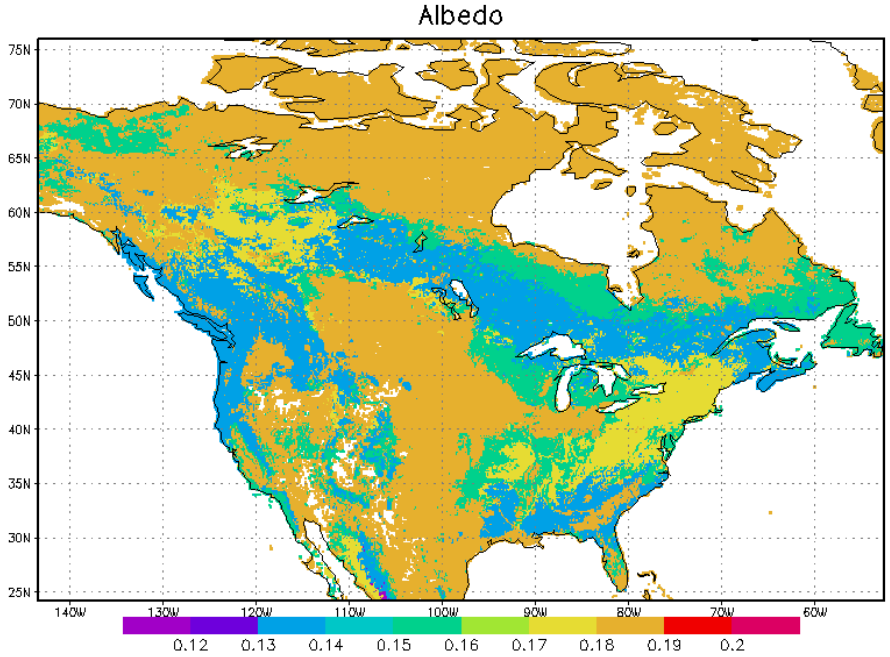
The combination of Daily Spin-up and Hourly Normal Run has pro and con

Dominant Vegetation Map

Dominant



Albedo



Evergreen needle leaf

Deciduous broad leaf

Shrub land

C4 Grassland/crop

C3 Grassland/crop

Evergreen broad leaf

Some in Southern America, but No appearance in dominant vegetation map

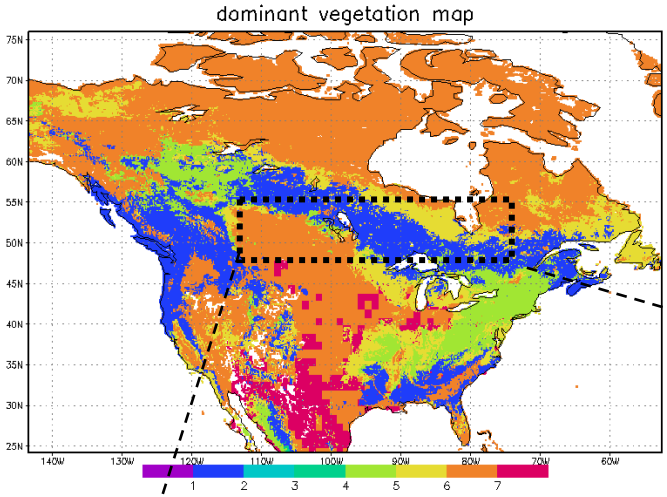
Deciduous needle leaf

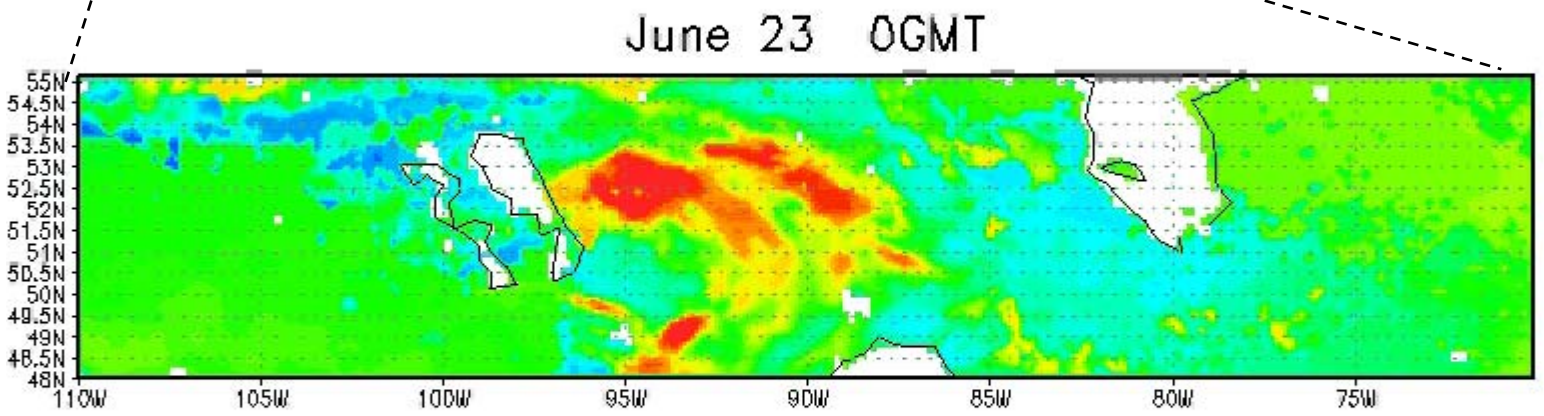
No appearance in NA

Albedo for each vegetation is set to the following number:

nef	0.14
ndf	0.14
bef	0.12
bdf	0.18
shrub	0.16
C3/C4 grass	0.19

Modelled Net CO_2 Flux





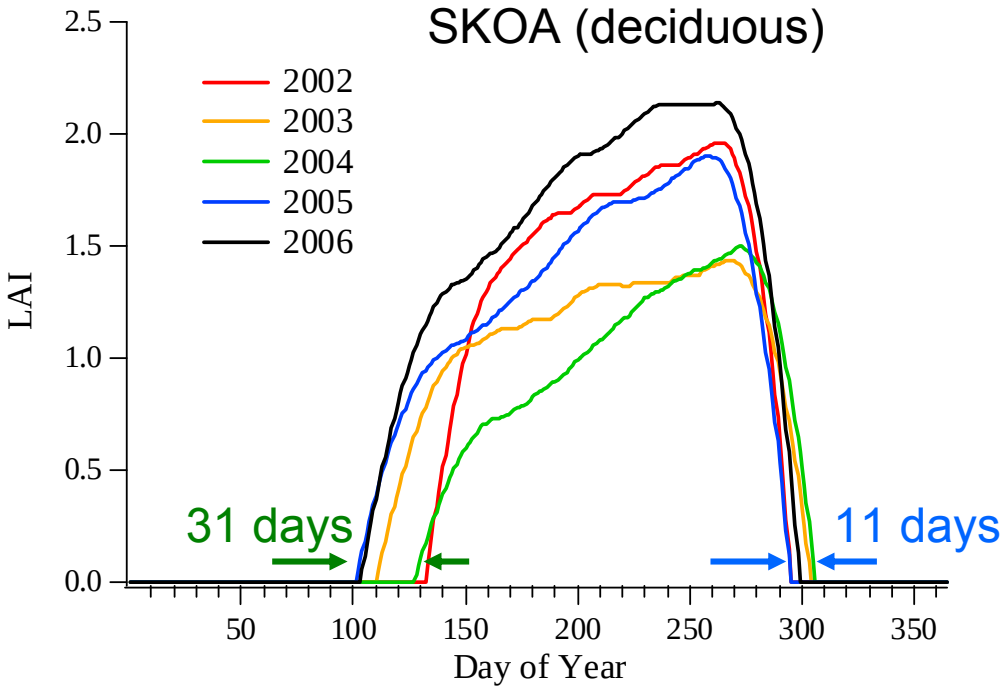
Uptake

Emission

[kg m^{-2} day^{-1}]

LAI and Albedo

- Interannual variation in maximum LAI
- Interannual variation in growing season start
- Less variation in growing season end



	2002	2003	2004	2005	2006
start	133	111	128	102	104
end	294	303	305	294	298

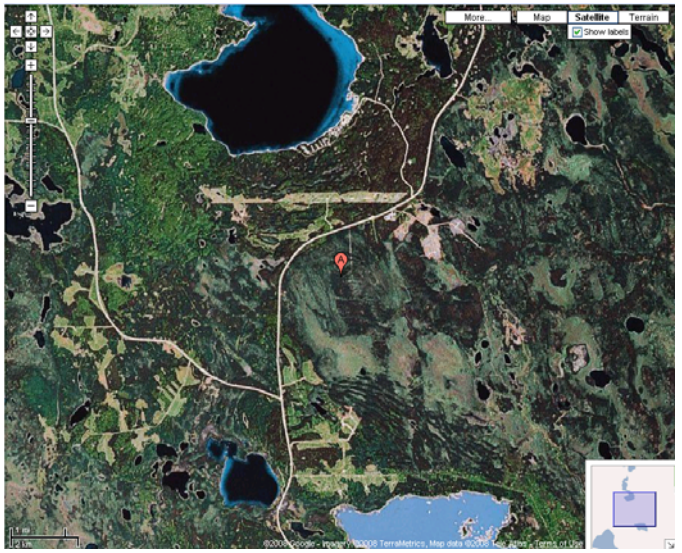
Unit: [day]

LAI Comparison: Conifer

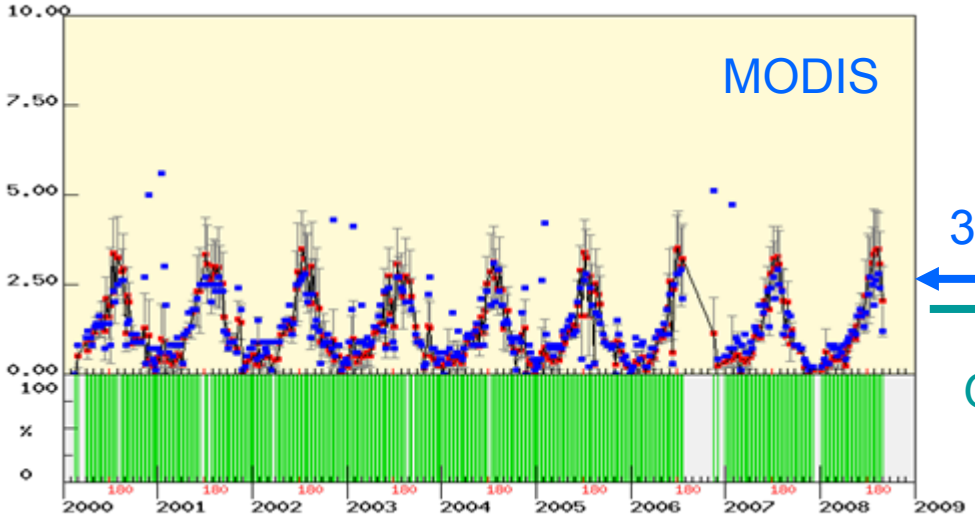
BERMS Old Black Spruce (54N, 105W)

Land coverage is highly variable

10km



- 7 kmx7 km mean

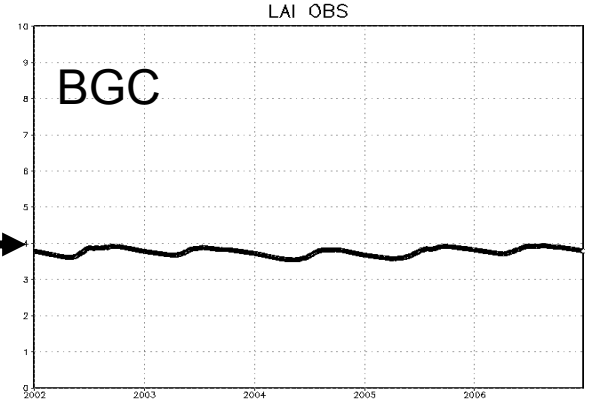


3.0

2.8

Ground

3.8

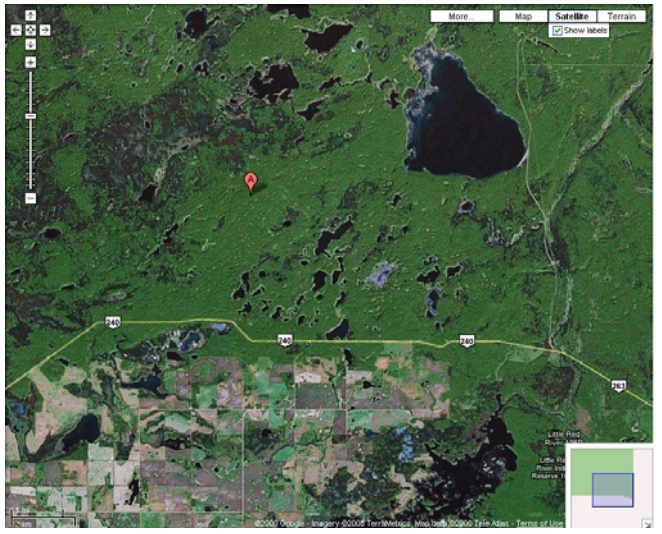


Overestimate evergreen LAI?

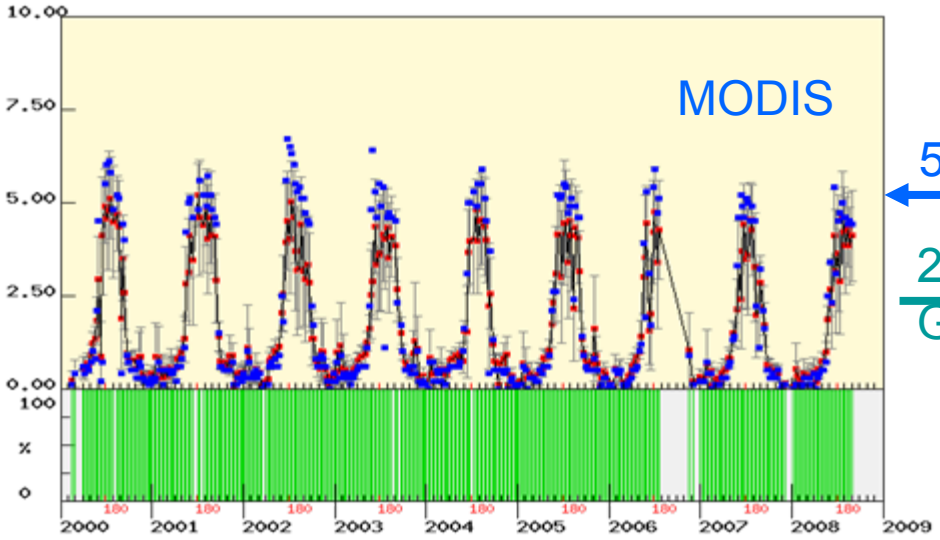
LAI Comparison: Deciduous

BERMS Old Aspen (53.6N, 106.2W)

Large land use change in the south



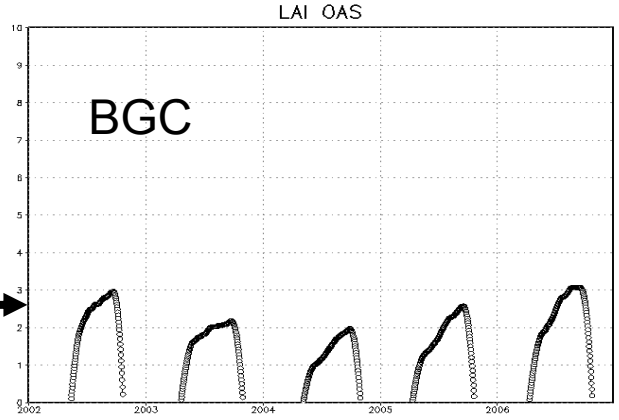
■ 7 kmx7 km mean



5.0

2.5 Ground

2.5



Underestimate deciduous LAI?

Comparison #2: NEP

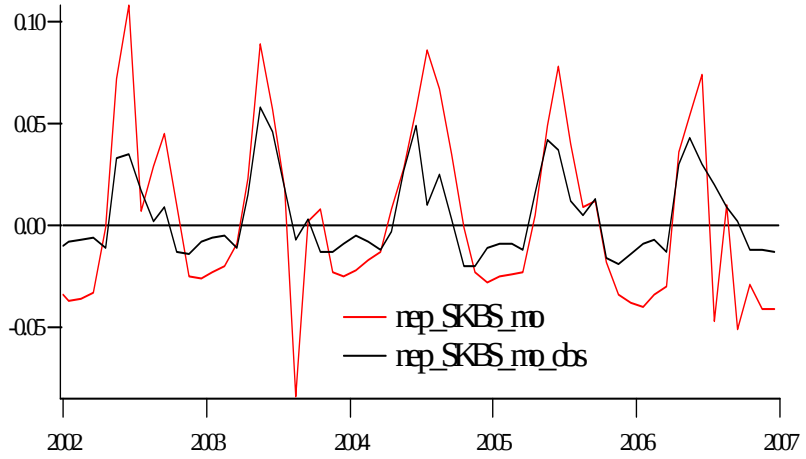
- Seasonal variations and anomalies

Unit: [kgC/m^2/mo]

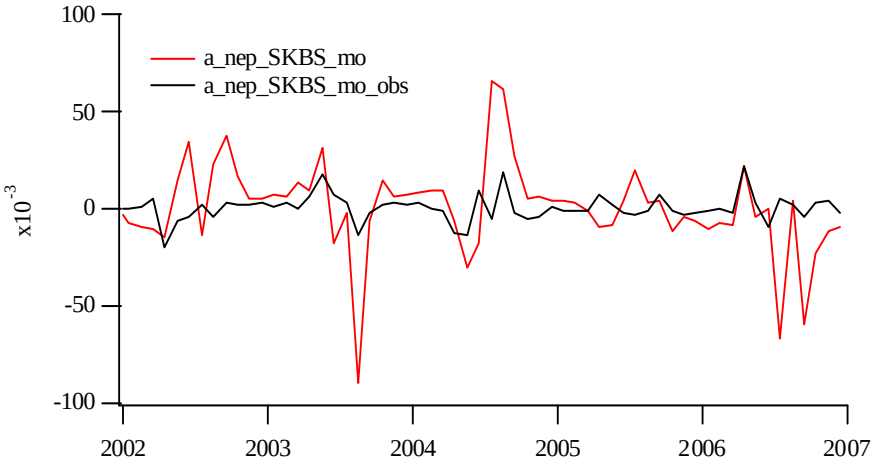
Monthly mean

Obs.
Model

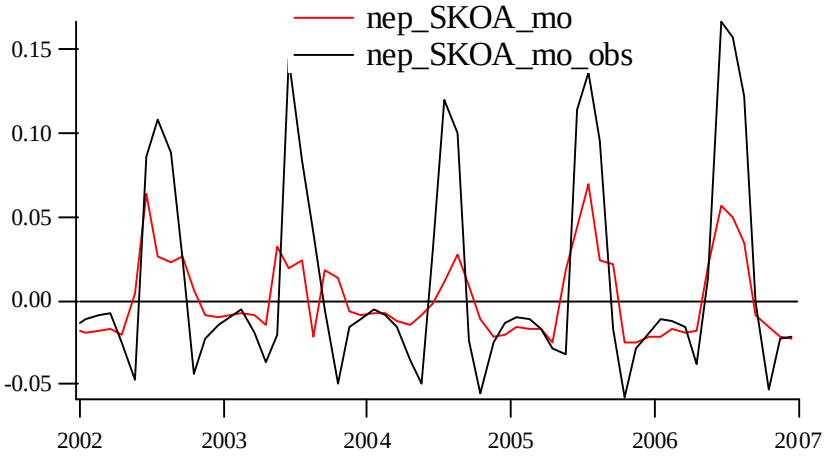
SKBS (conifer)

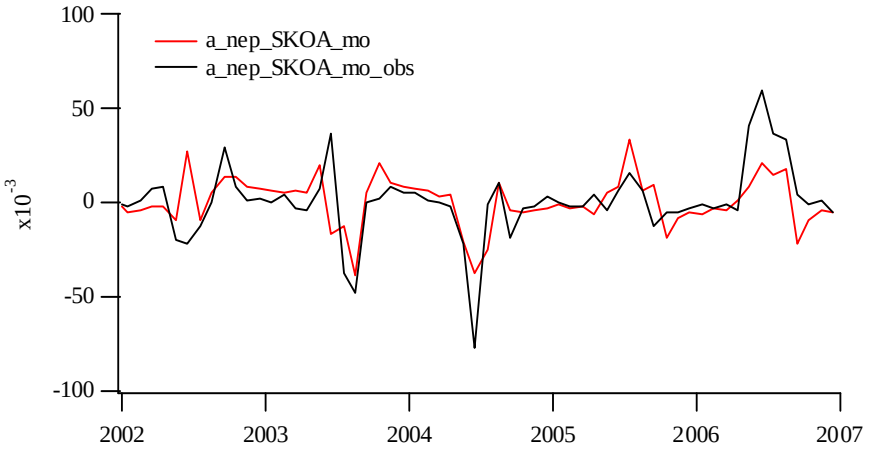


Anomalies from 5-year averaged monthly mean



SKOA (deciduous)

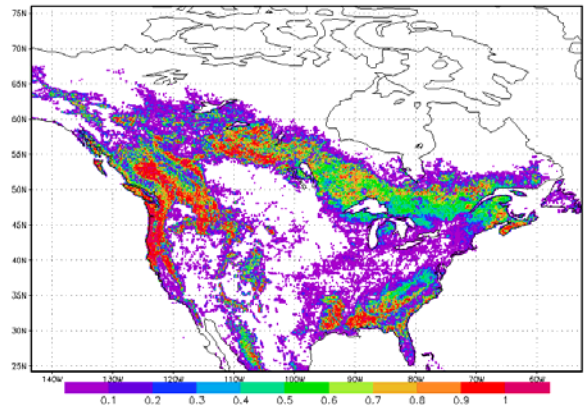




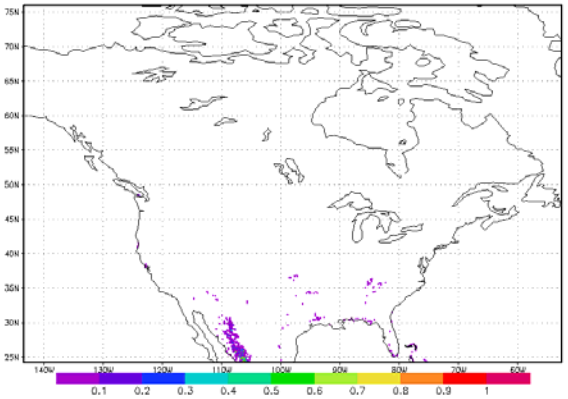
Vegetation Fraction Map in NA

No Deciduous Needle Leaf

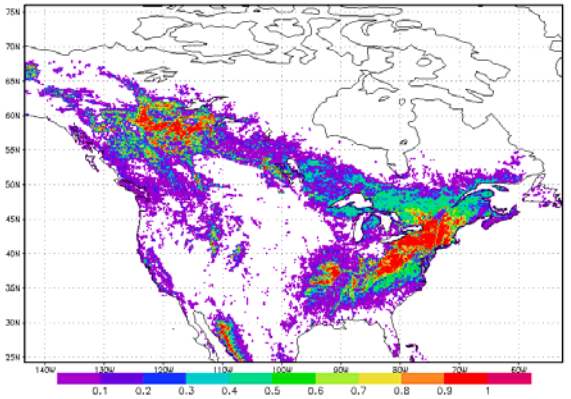
Evergreen needle leaf



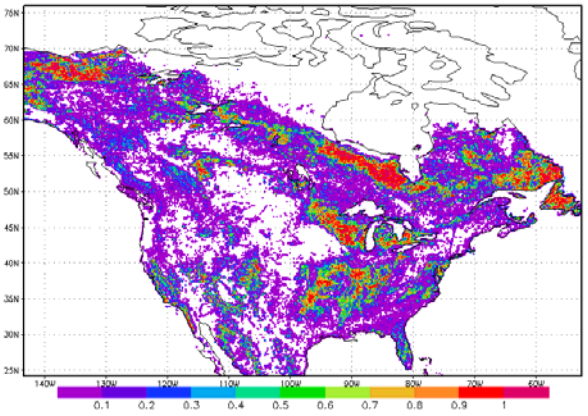
Evergreen Broad leaf



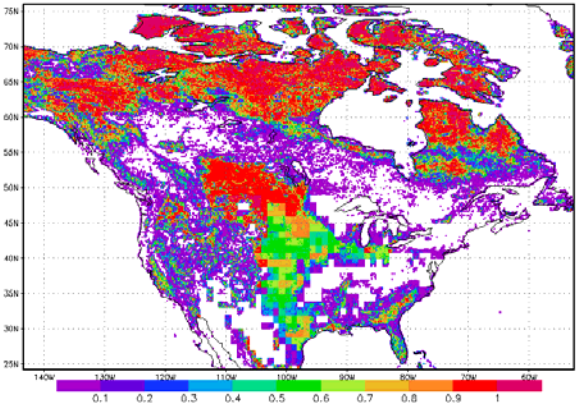
Deciduous Broad leaf



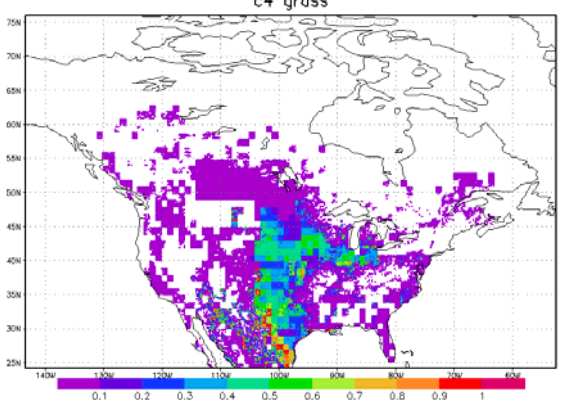
Shrub



C3 Grass



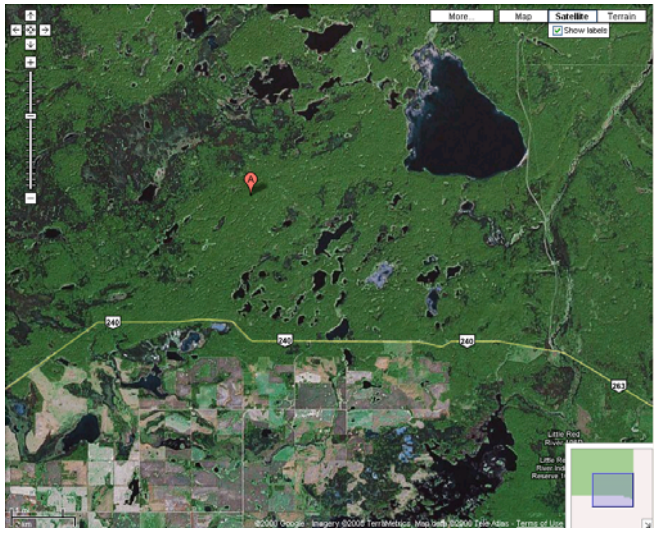
C4 Grass



Land types (Grass+ Crop) are divided based on C4 map

Mixed Vegetation: SKOA

BERMS Old Aspen (53.6N, 106.2W)



Site : Deciduous Broadleaf Forest

USGS/BGC :

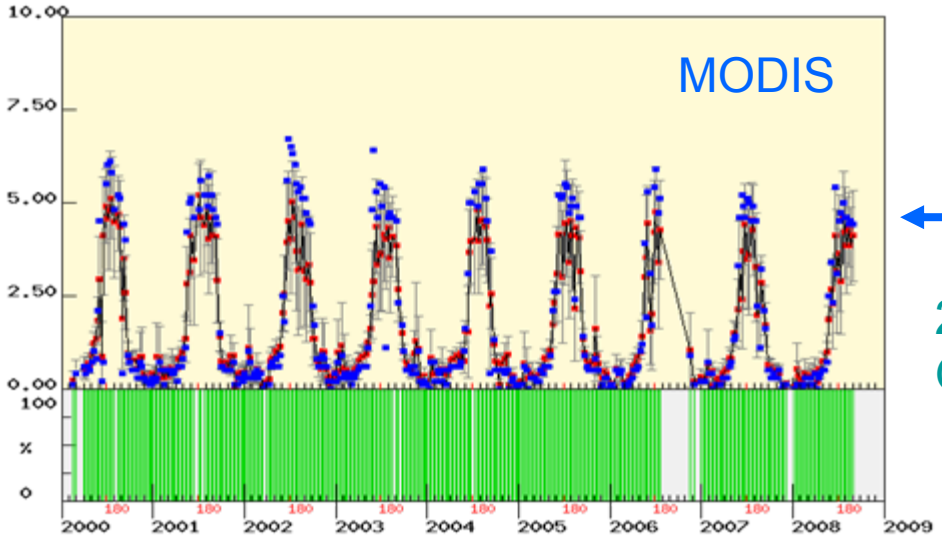
Evergreen Needle Leaf	**: 8.2 %**
Deciduous Broad Leaf	**: 57.0 %**
Shrub	**: 33.6 %**
C3grass	**: 1.2 %**

Agreement, but shrub has also large coverage

Large land use change in the south, but it seems not to be included in USGS map.

Mixed Vegetation: SKOA

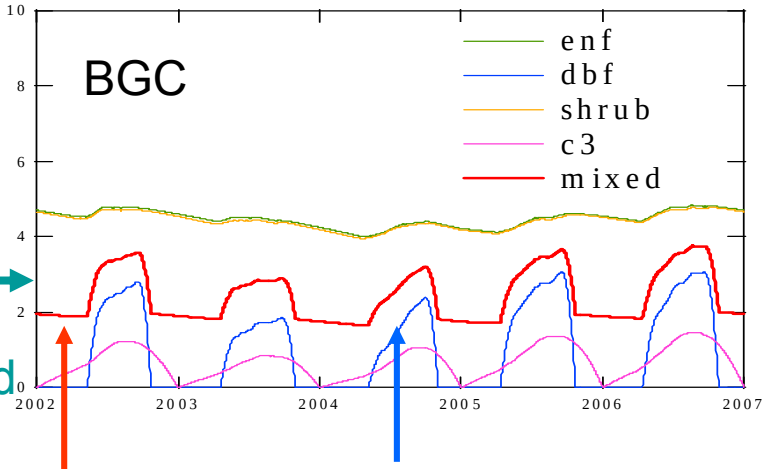
BERMS Old Aspen (53.6N, 106.2W)



5.0

2.5

Ground

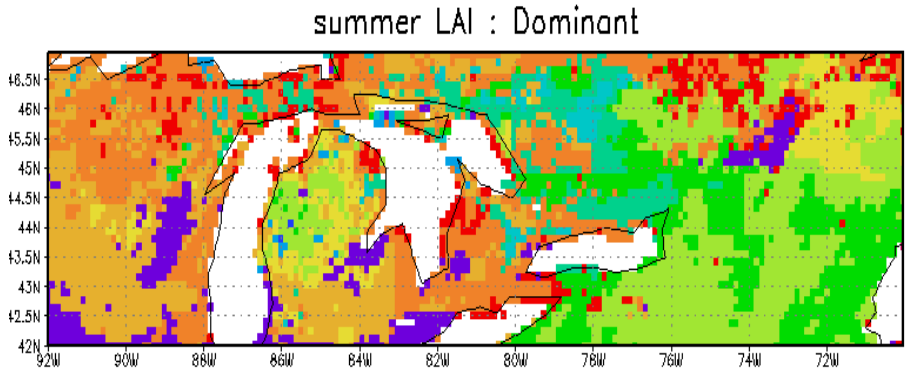


Deciduous Broadleaf Forest

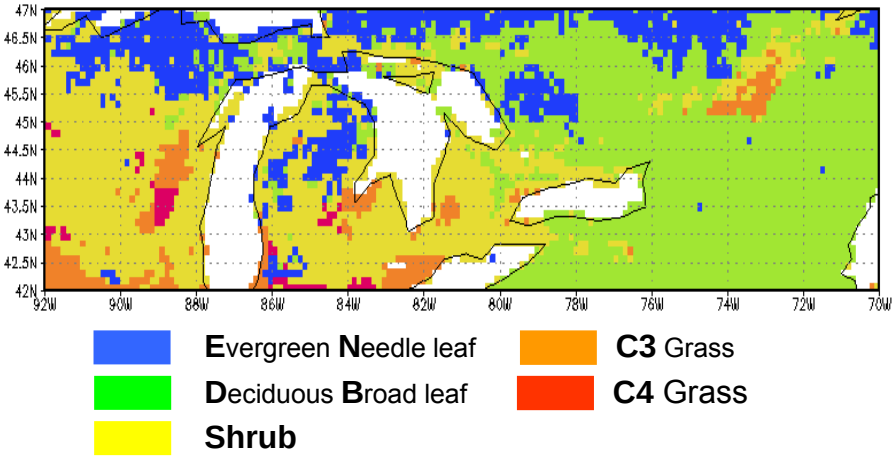
Modelled-LAI is increased slightly.

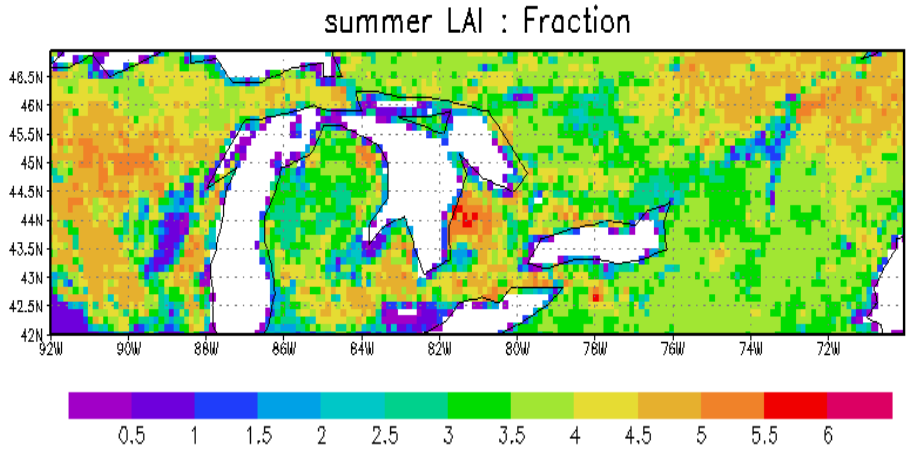
Not clear if the mixed vegetation is better for this location in regards to LAI

Dominant vs. Fraction : LAI

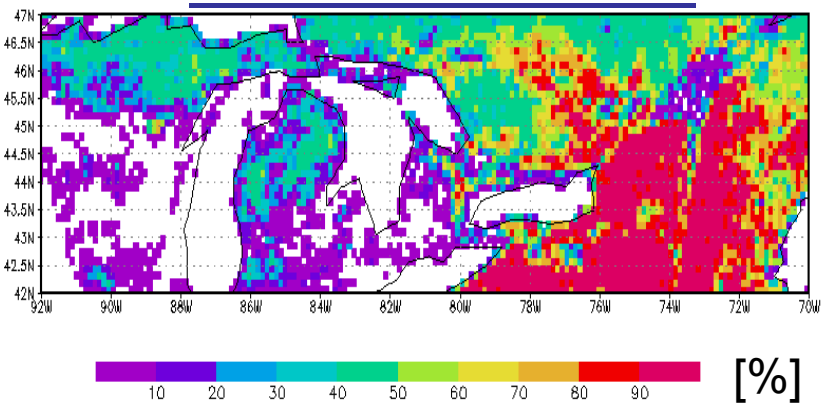


Dominant Ecosystem





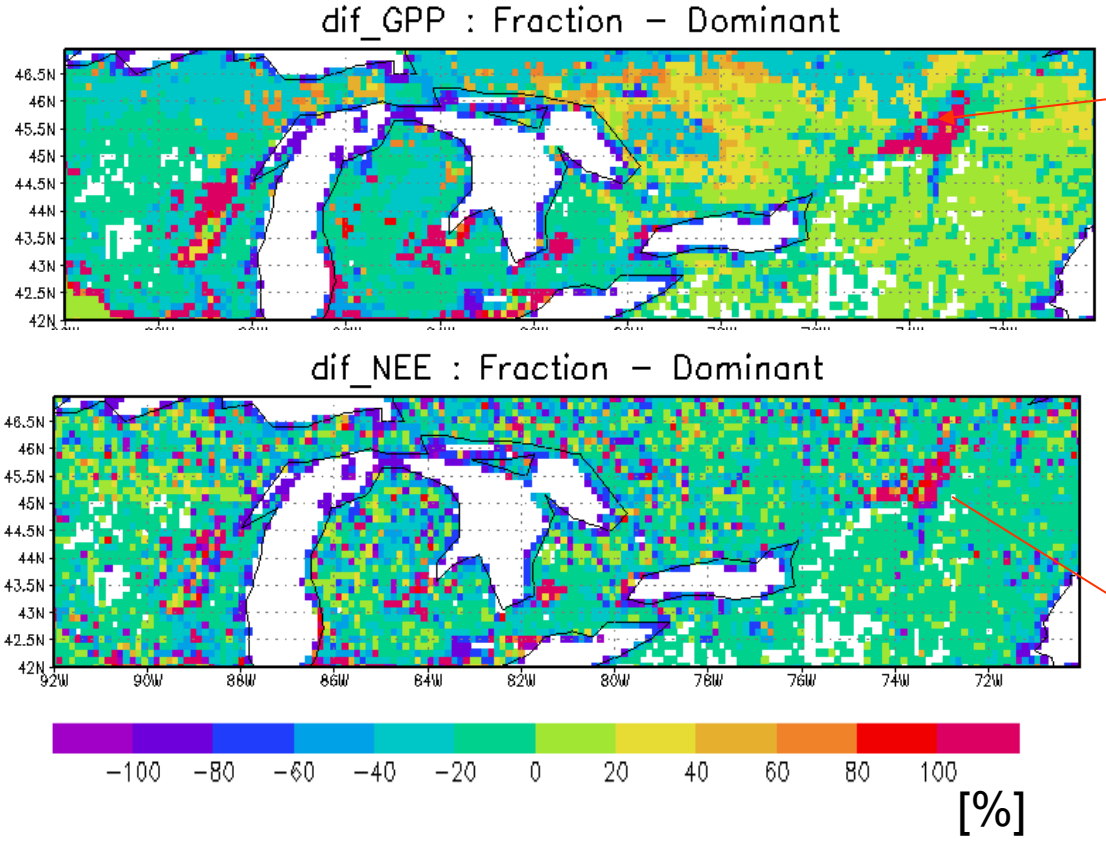
Fraction of Deciduous

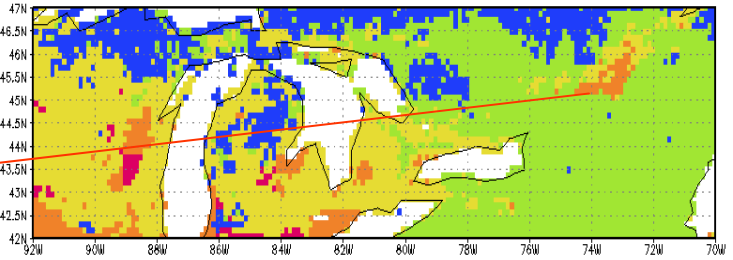


Grids with 30-40% deciduous forest may turn into other ecosystem (eg., shrub)

Dominant vs. Fraction : Fluxes

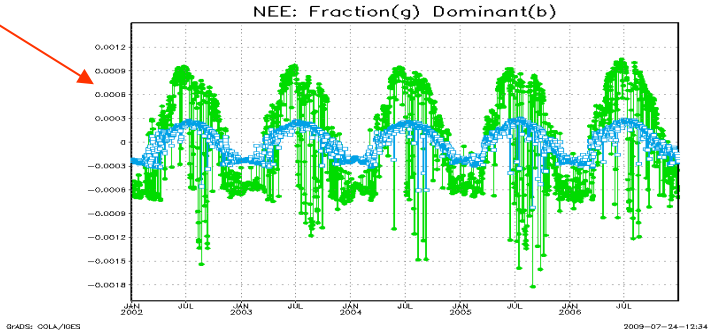
(Fraction-Dominant) /Dominant





Evergreen **N**eedle leaf
Deciduous **B**road leaf
Shrub
C3 Grass
C4 Grass

Dominant-Grass
More Exchange and More Uptake



Trees increase the productivity, especially evergreen needle leaf, while grasses reduce the productivity

Calibration/Validation of regional scale GHG flux (scaling problem)

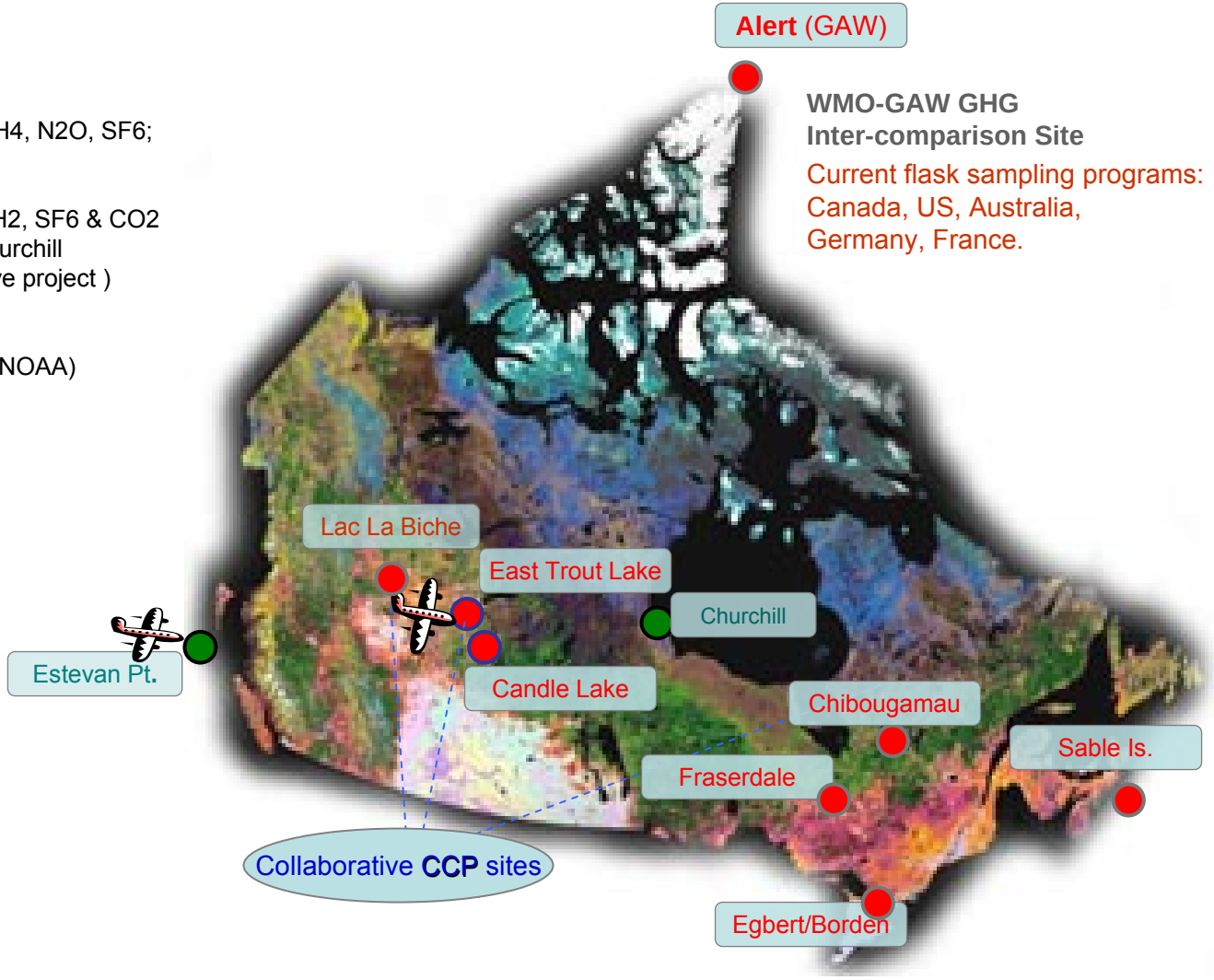
- To understand how the regional (ecosystem or other) flux is related to the concentration? (CO2 or GHG in general)
  - GHG concentration is the interaction between fluxes and atmospheric transport (up scaling of flux)
  - Use GEM to simulate GHG concentration (given the flux)
  - Compare to EC continuous GHG concentration measurements
  - GHG measurements include CO2 and CH4 (ecosystem and anthropogenic)

Environment Canada's Greenhouse Gases Measurements Network

In situ and flask CO, CO2, CH4, N2O, SF6; Flask H2, and CO2 isotopes

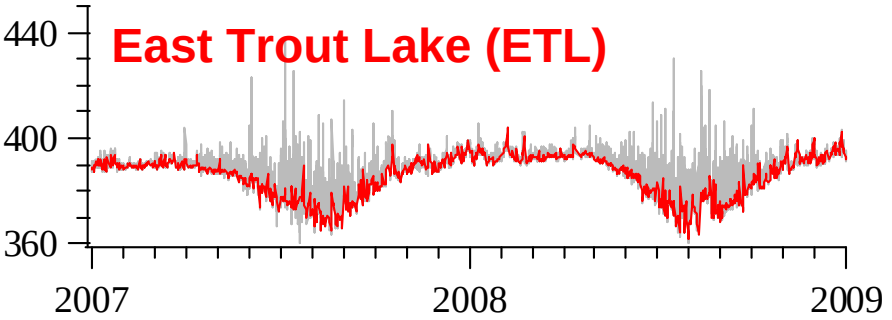
Flask CO, CO2, CH4, N2O, H2, SF6 & CO2 isotopes only at E. Pt and Churchill (EC/NIPR, Japan collaborative project)

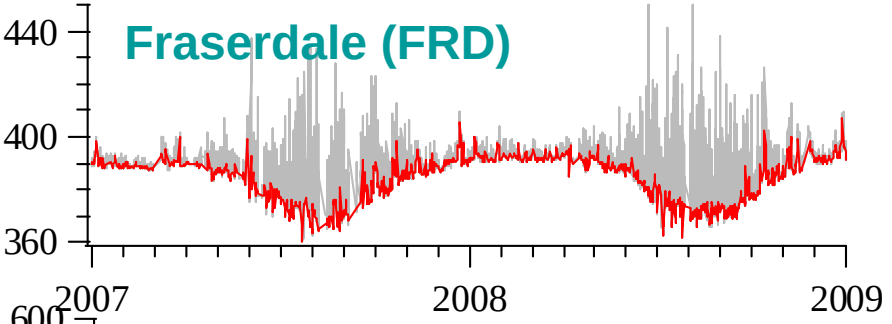
Regular vertical profiles (EC/NOAA)



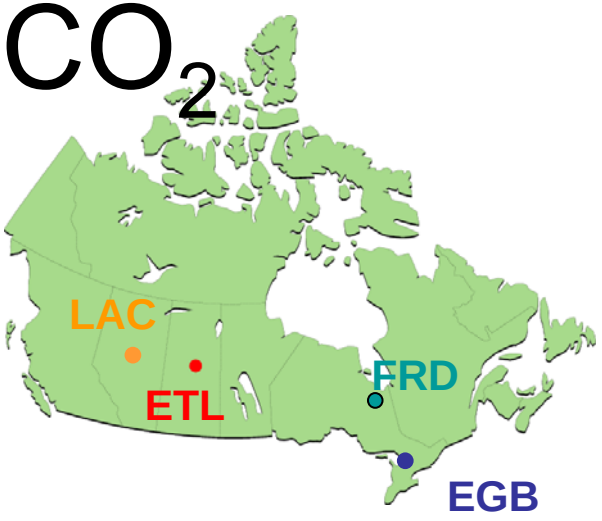
Environment Canada Environnement Canada

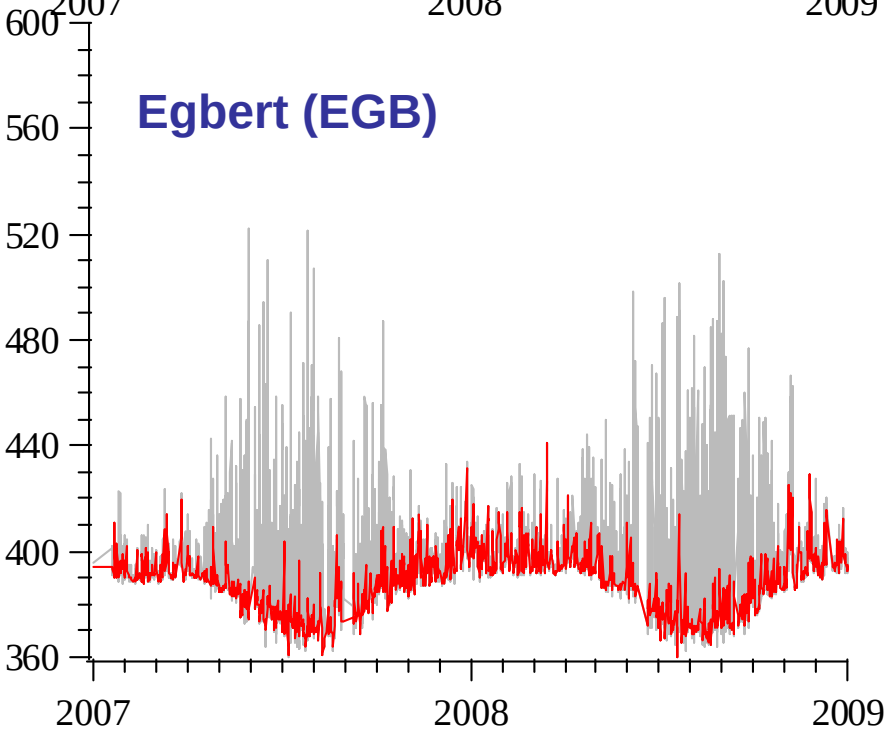
Observed CO_2

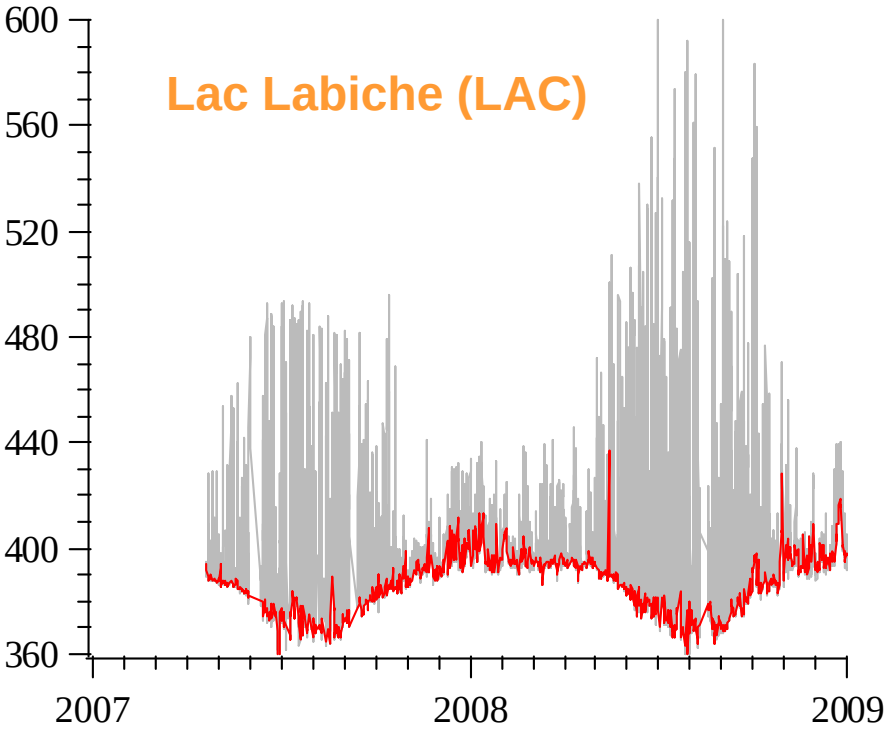




Hourly
Daily

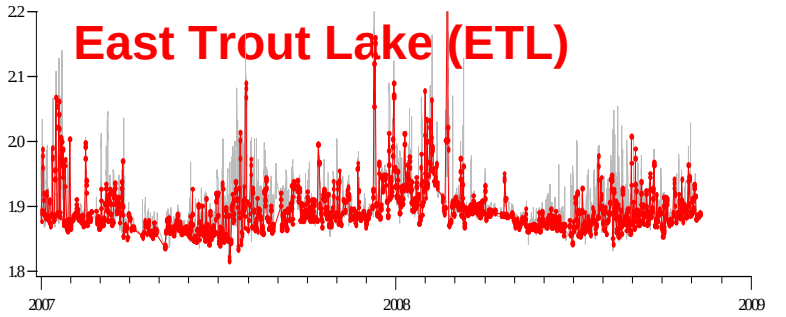


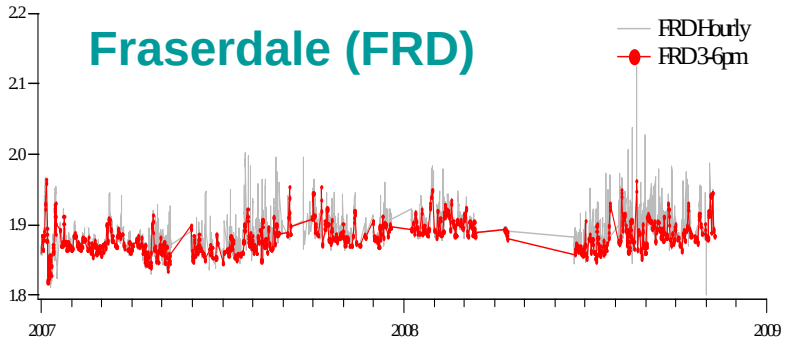


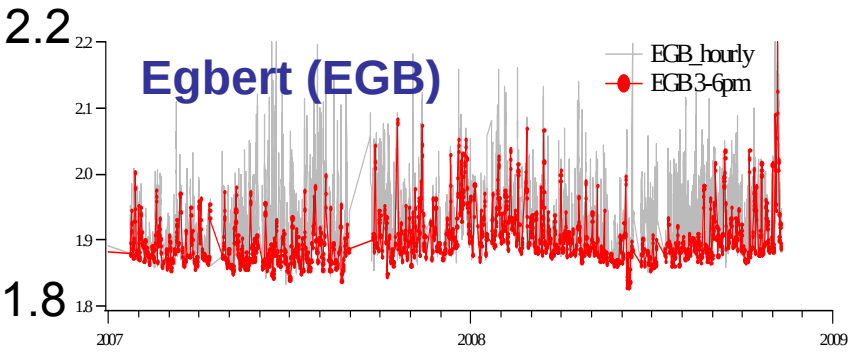


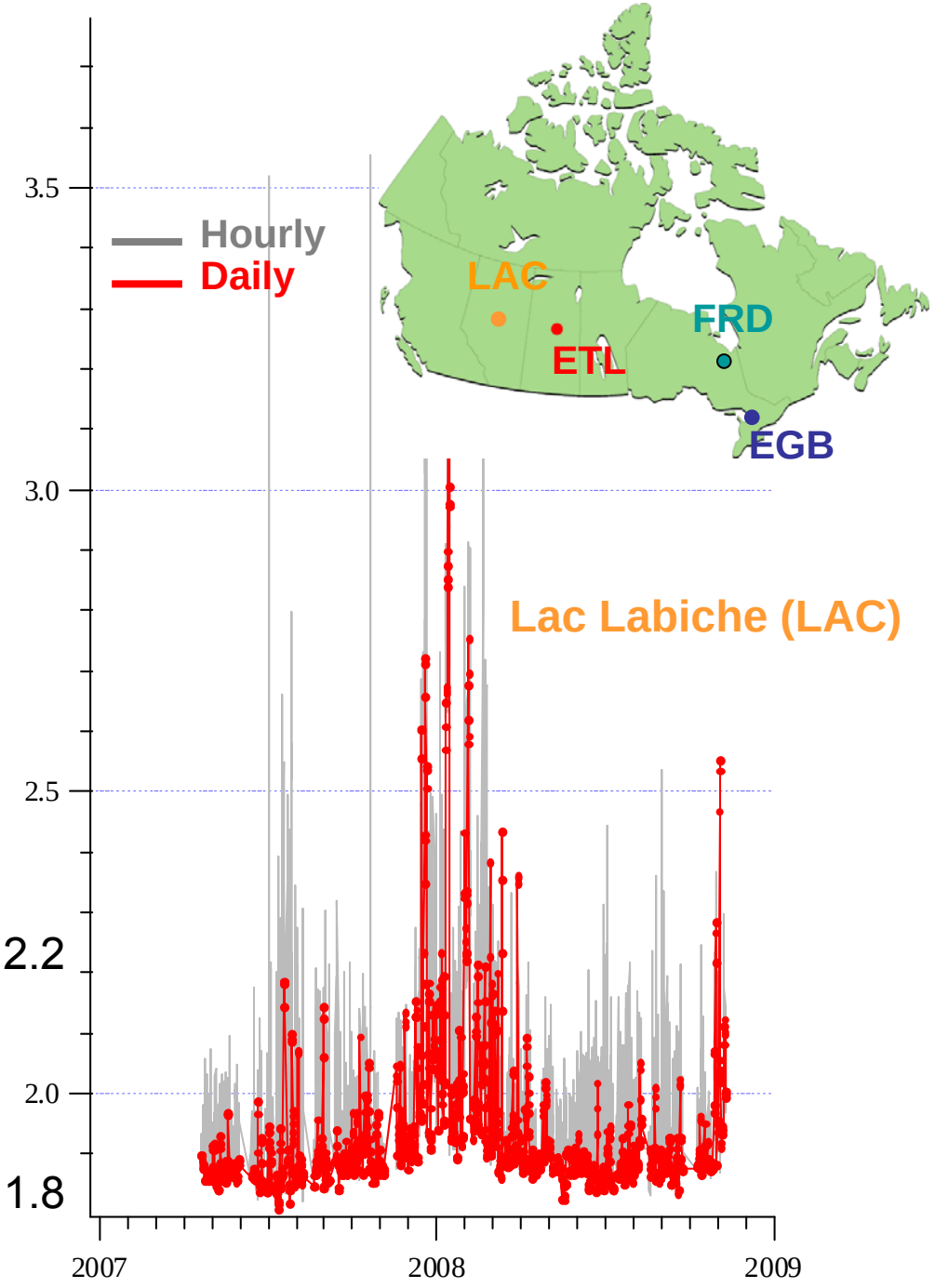
Observed CH_4

Short-term variations might be a indicator of local/regional sources



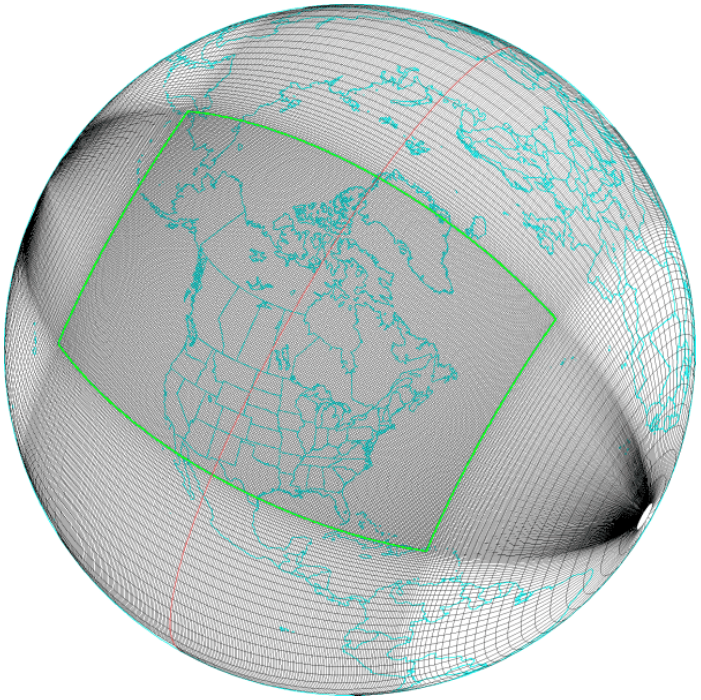






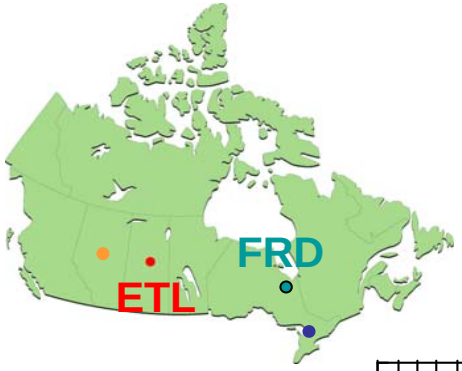
Modelling concentration in GEM

- To simulate synoptic/short-term variations, we need more high-resolution modeling with ‘accurate’ transport

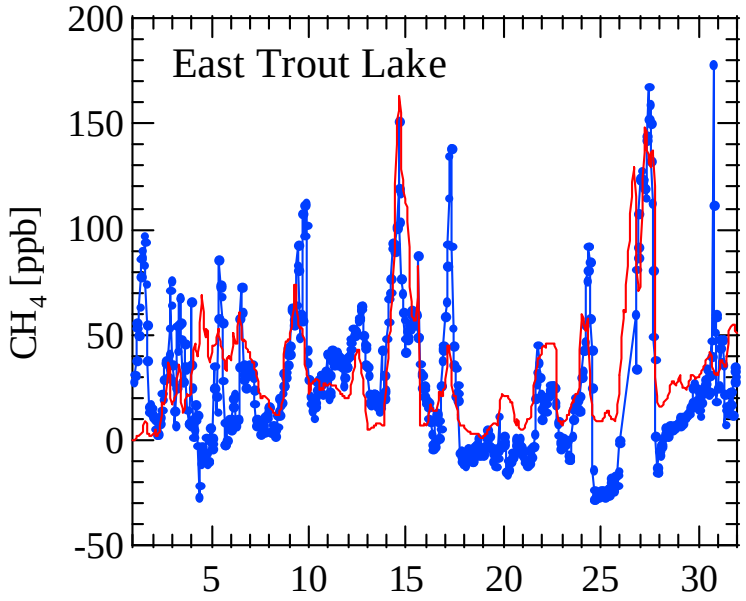


- Weather forecast model
- Short time scale Δt = ~10 min
- variable resolution domain ΔL = ~15 km
- Time invariant fluxes

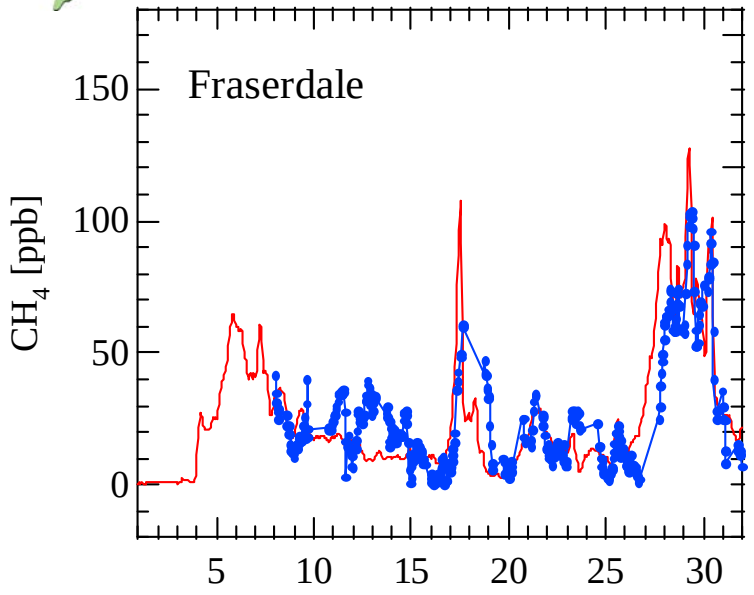
CH_4 Model vs Obs : 2008 January



ETL



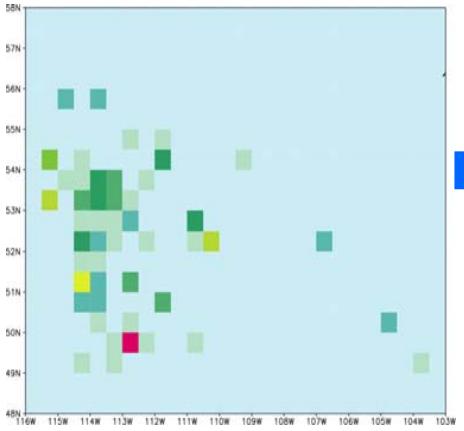
FRD



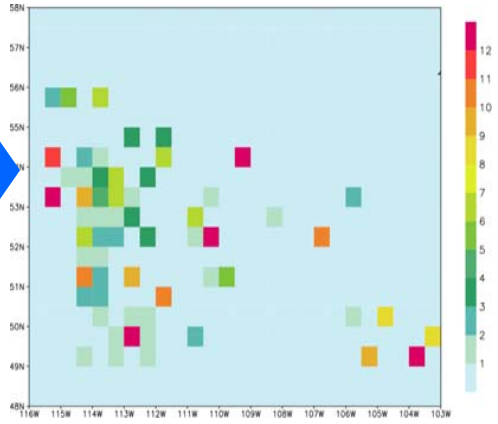
Modeled CH_4 with EC & EDGAR

AB&SK

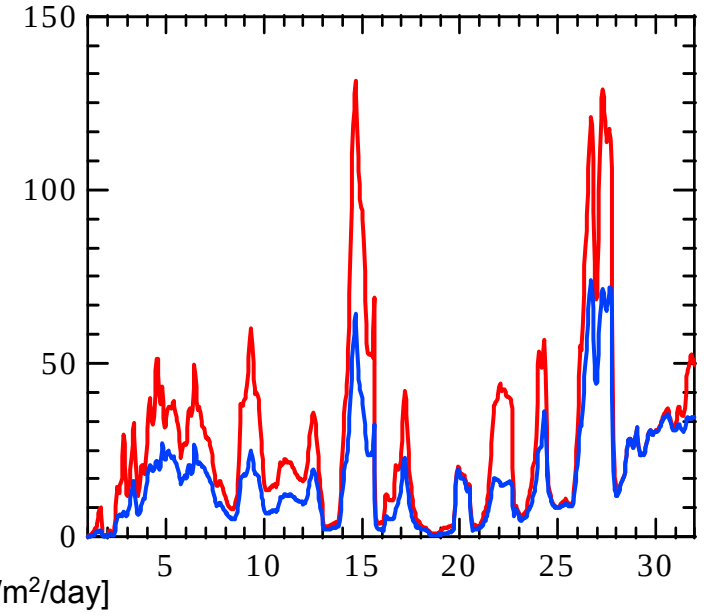
EDGAR



EC

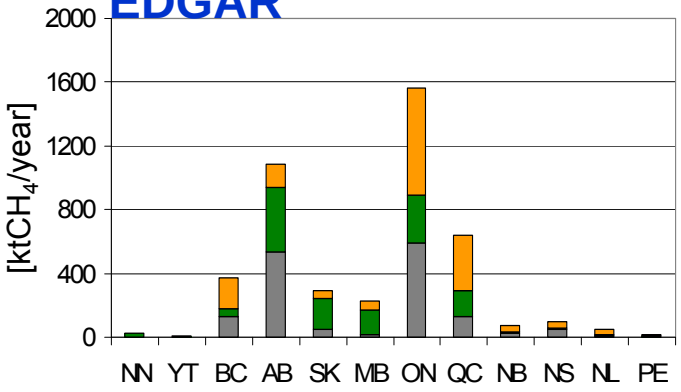


Reflect the Emission Difference

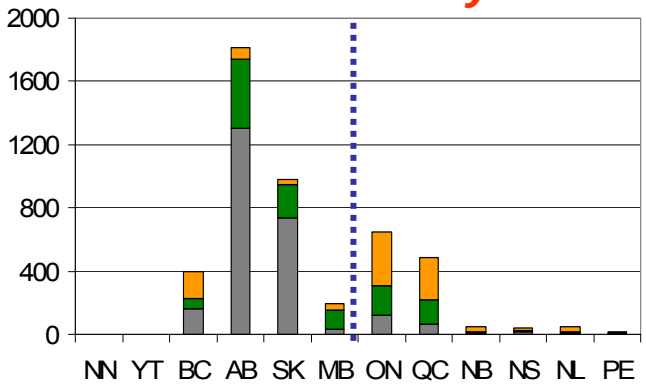


Provincial

EDGAR

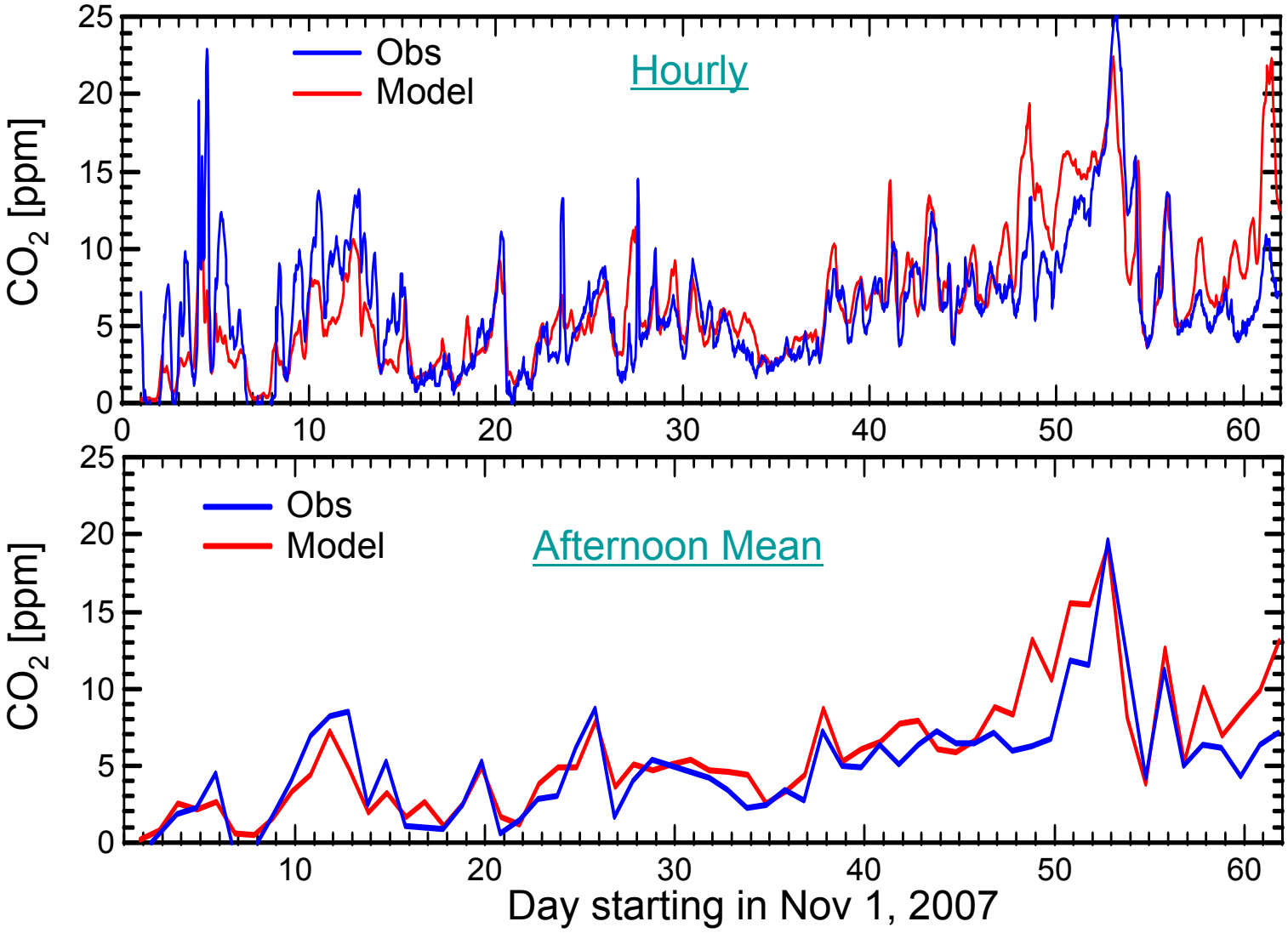


EC2008 Inventory

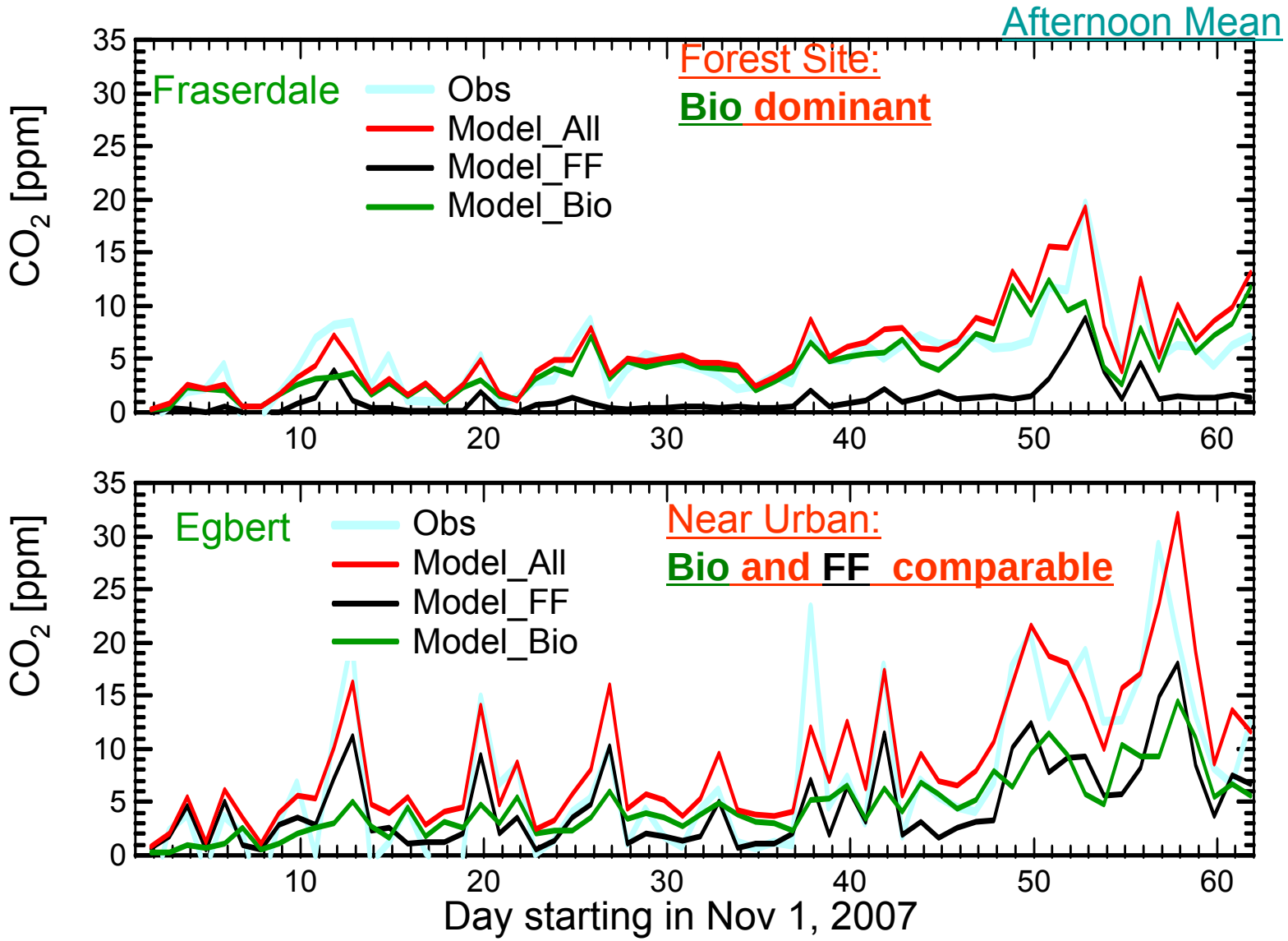


Model vs Obs : Fraserdale

GEM-model appears to capture diurnal and synoptic variability



Model : Bio/FF Partition



SMAP carbon cycle modelling

- Use improved GEM forcing with assimilated SMAP soil moisture and F/T
  - Better soil temperature and moisture could improve soil respiration modelling
- Assimilate MODIS LAI (also GPP/NPP) into ecosystem models
  - Provide more constrain on photosynthesis and plant respiration
- Develop GHG concentration modelling in GEM to evaluate/validate model fluxes regionally
  - Synoptic concentration is the integrated signal from the regional fluxes (ecosystem models, CarbonTracker, SMAP NEE)
- Different ecosystem models (Biome-BGC, CTEM, BEPS …) useful for a comprehensive GHG data assimilation system
  - Necessary component for a more complete GHG data assimilation model for remote sensing and physical sampling measurements
  - Different ecosystem models provide better uncertainty estimates (Biome-BGC, CTEM, BEPS …)