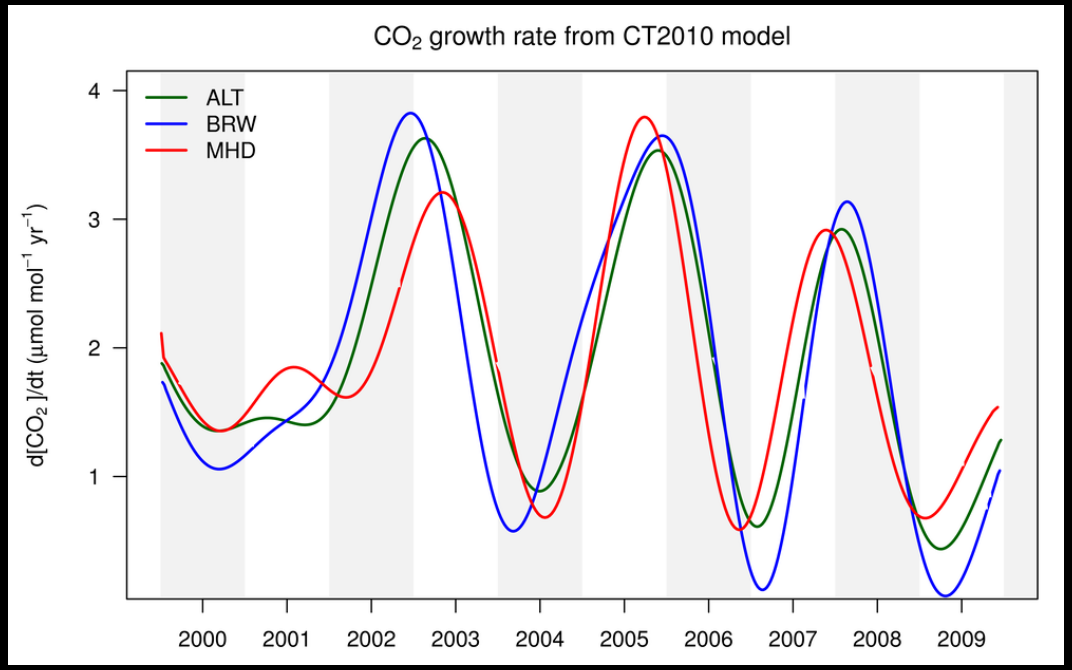
Exploring the Recent Biennial Cycle in Observed CO_2 Growth Rate using CarbonTracker

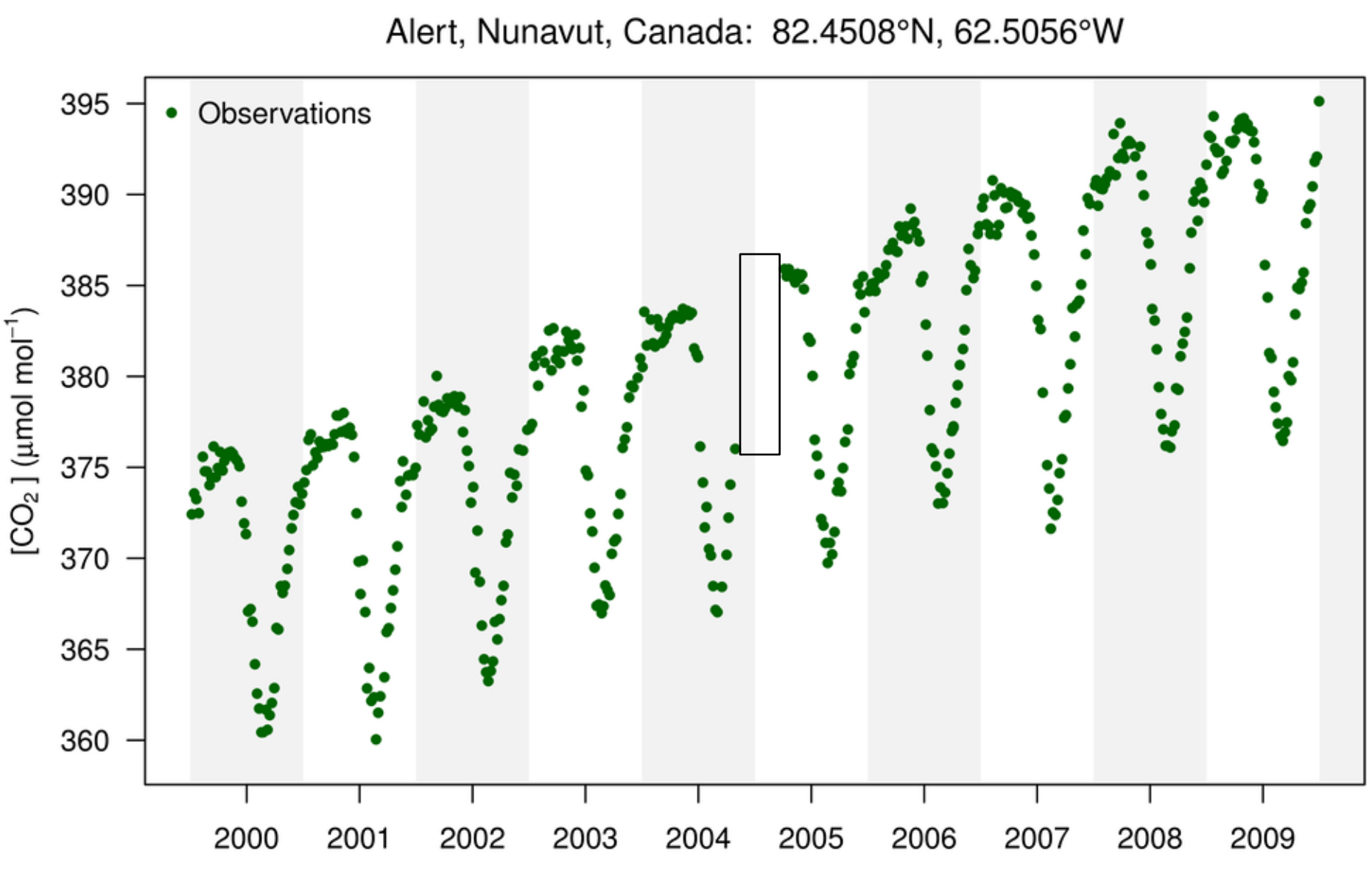


Andy Jacobson

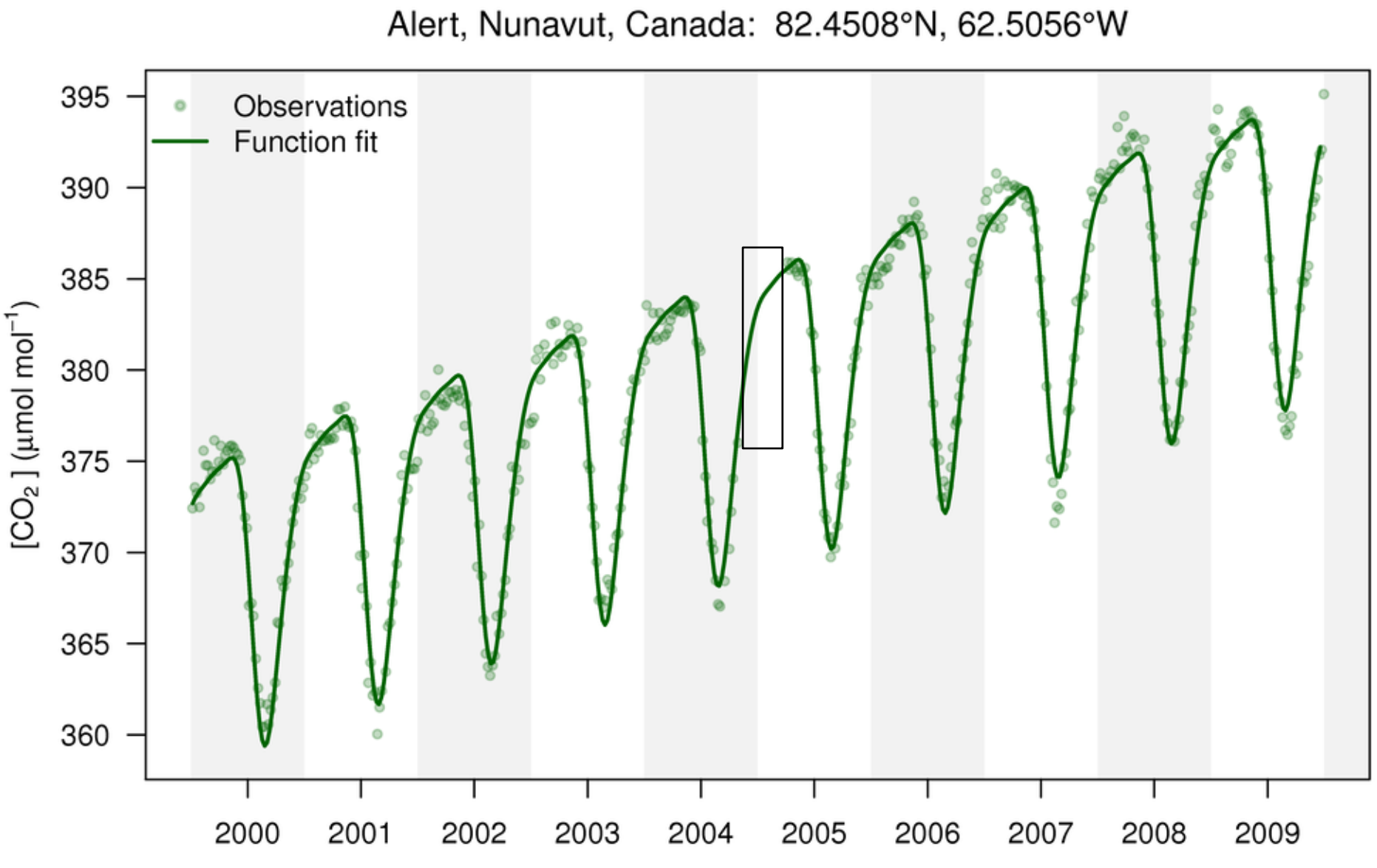
University of Colorado and
NOAA Earth System Research Laboratory

Tom Conway and Ken Masarie
NOAA Earth System Research Laboratory

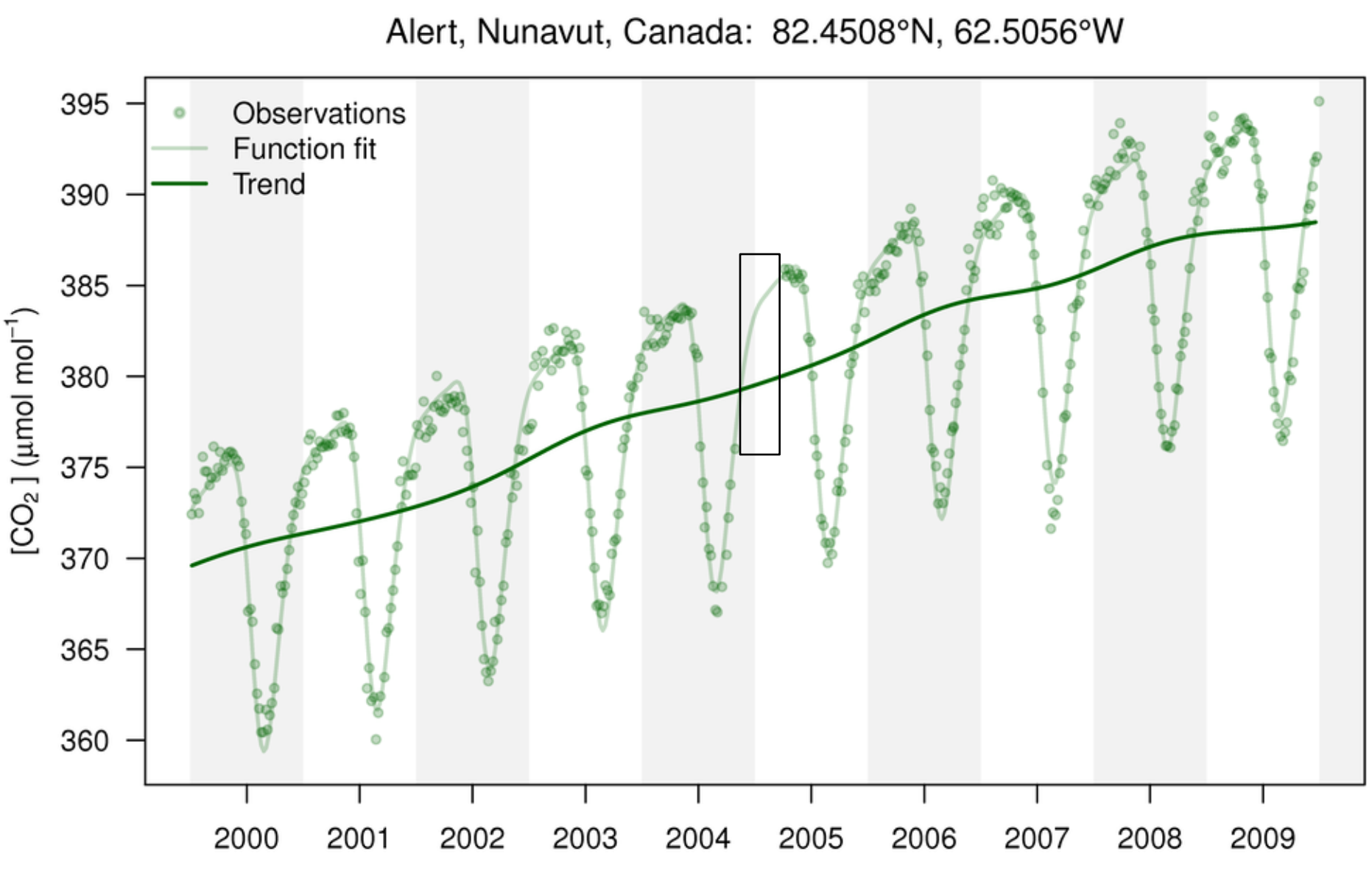
How is growth rate estimated?



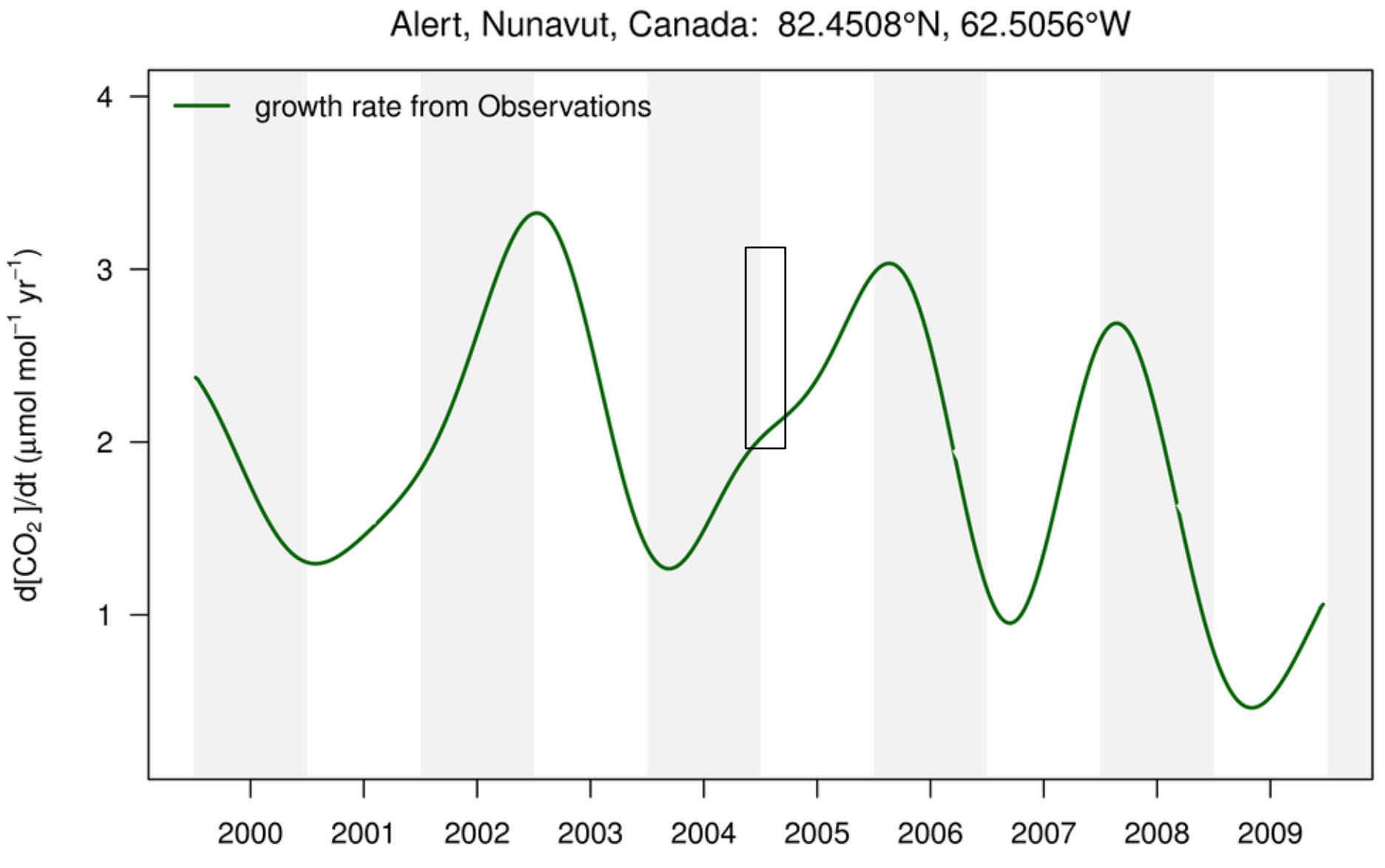
How is growth rate estimated? - CCGCRV model fit



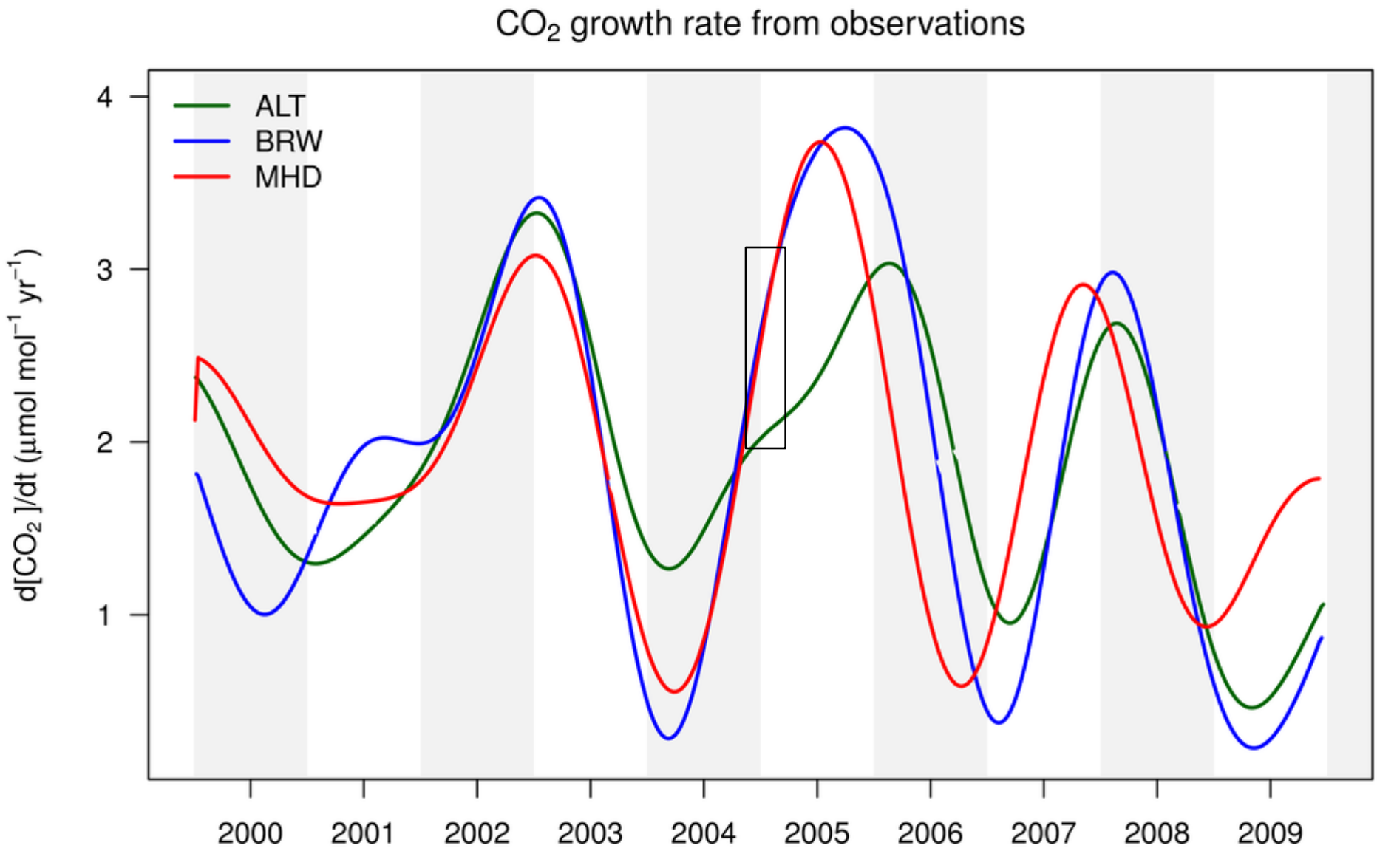
How is growth rate estimated? - Trend is polynomial plus LPF resids

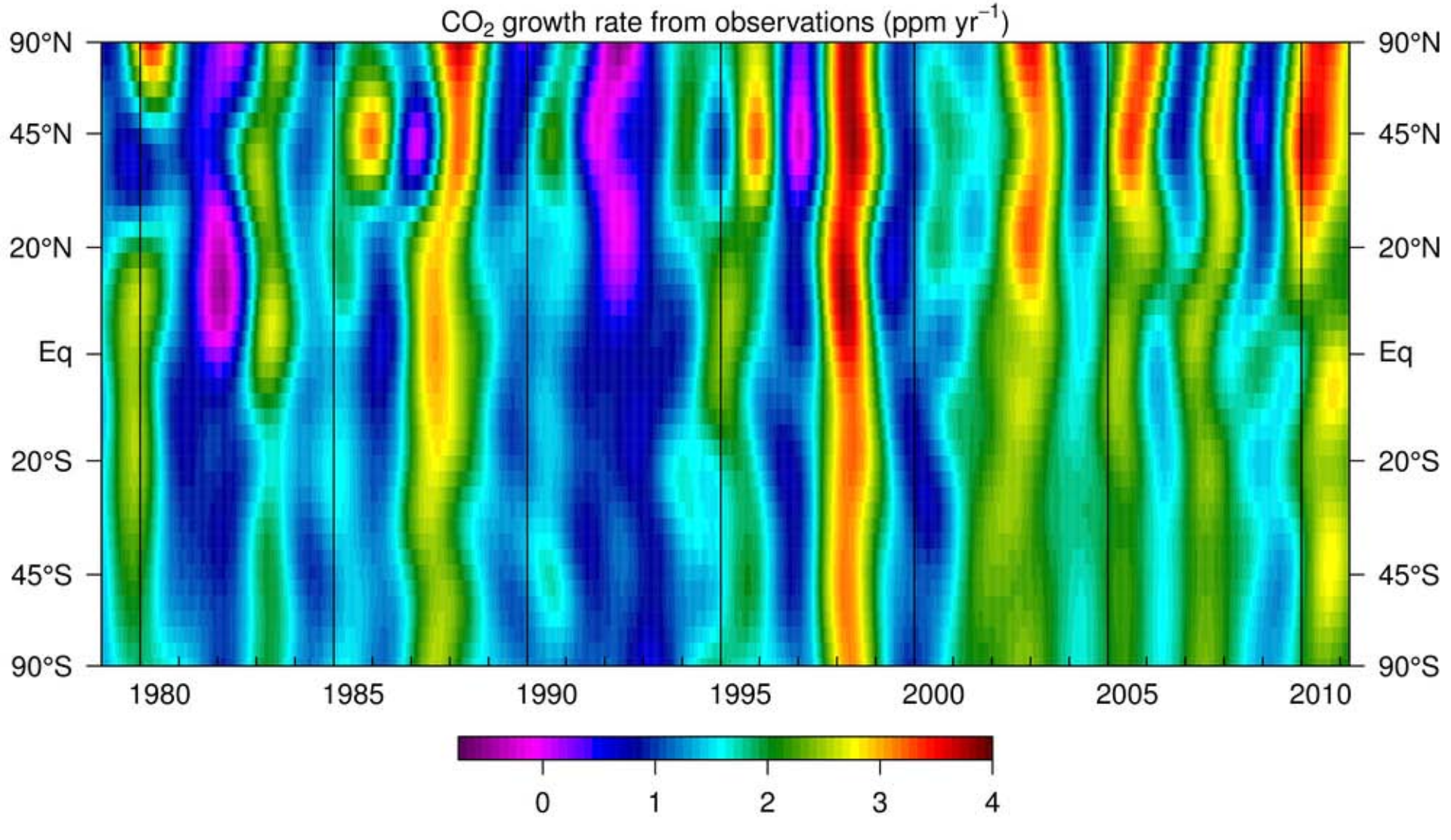


How is growth rate estimated? – As the time derivative of trend line

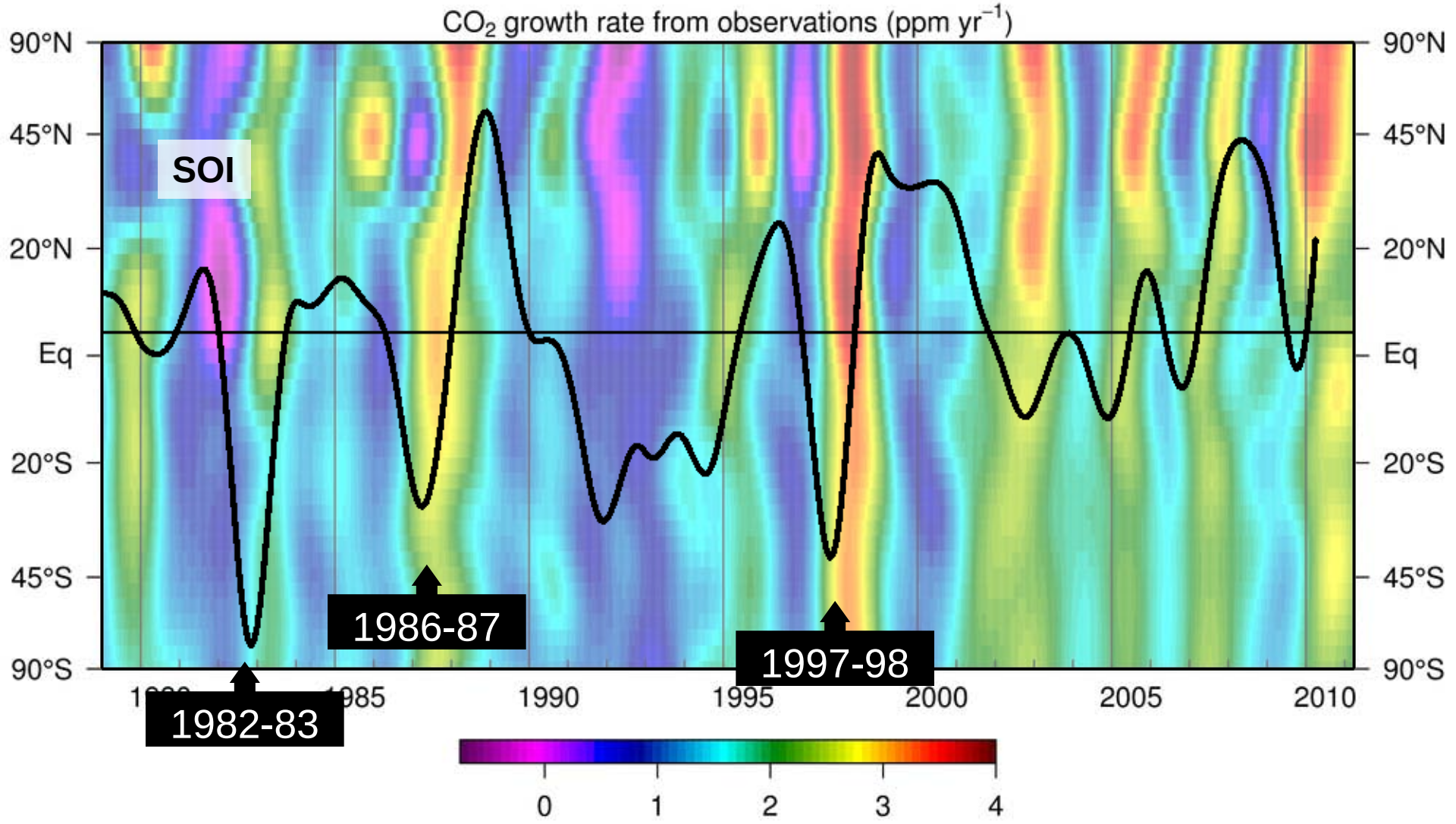


Alert missing data cause growth rate blip?

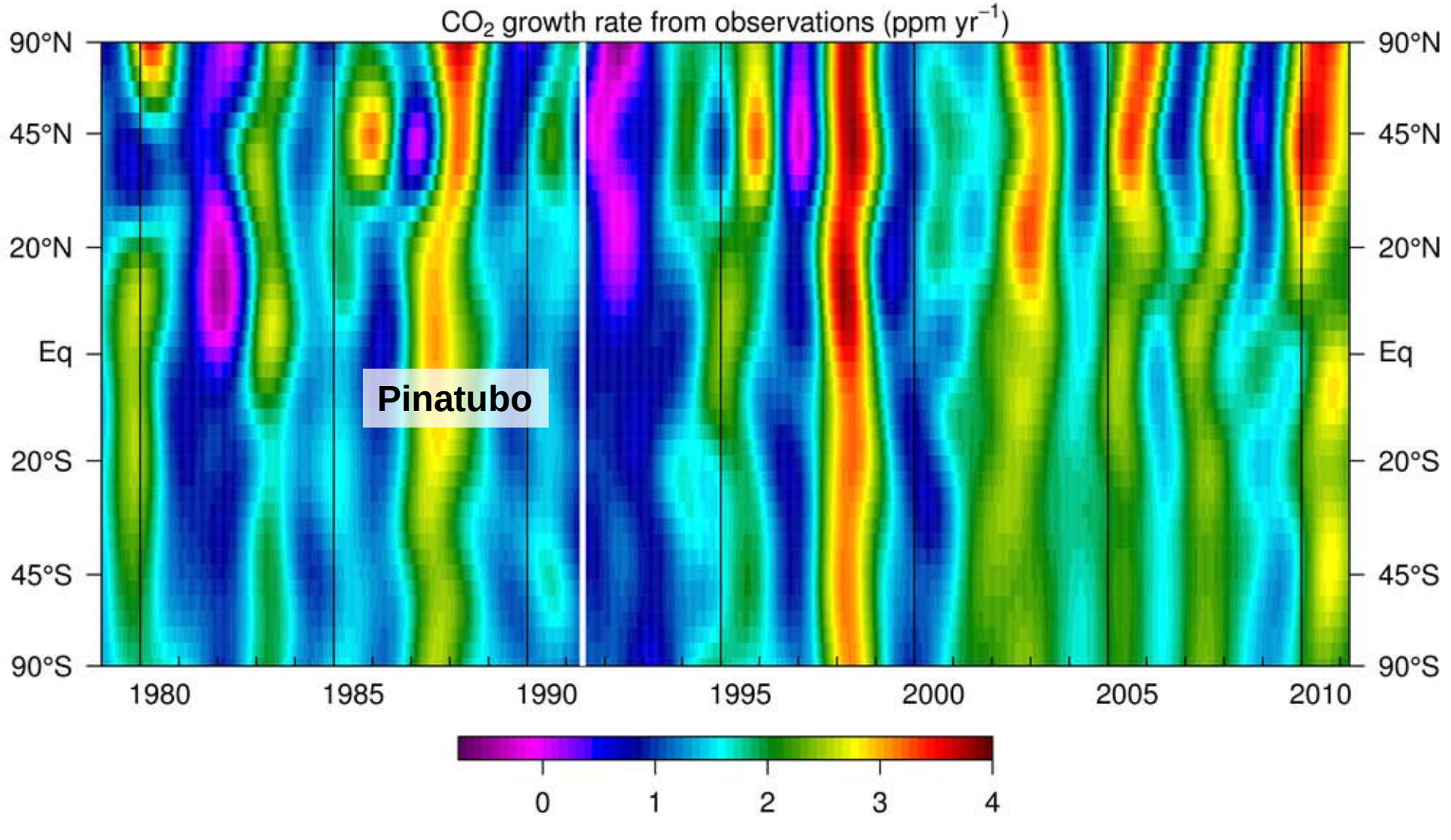



CO_2 growth rate from observations (ppm yr^{-1})
90°N
45°N
20°N
Eq
20°S
45°S
90°S
1980
1985
1990
1995
2000
2005
2010
0
1
2
3
4

Previous global-scale growth rate features are relatable to ENSO



Previous global-scale growth rate features are relatable to ENSO and Pinatubo

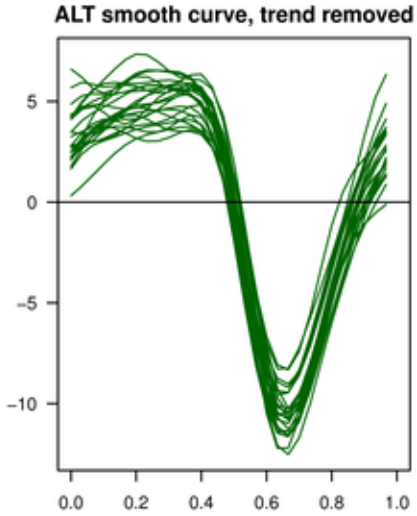


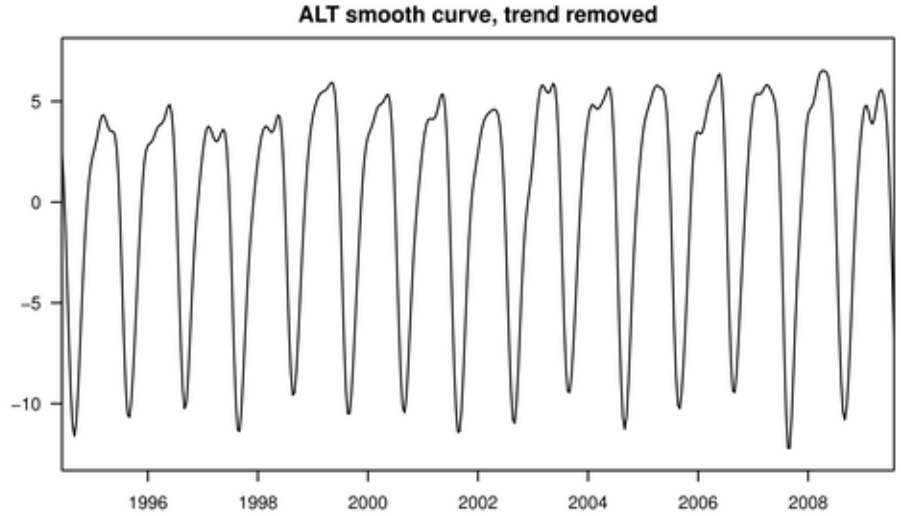
Biennial cycle in CO_2 growth rate:

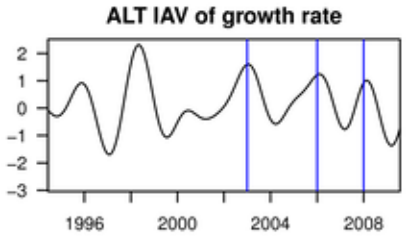
An artifact of the curve fit?

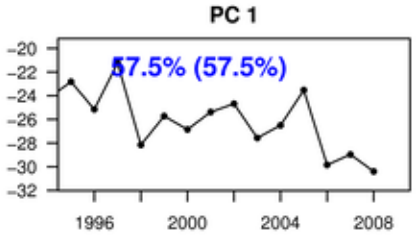
Interannual variabilty in fluxes?

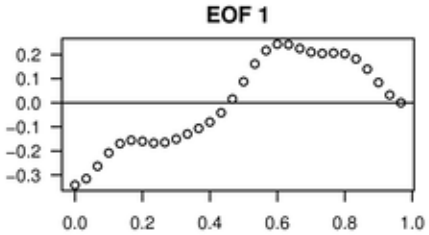
A feature of transport?

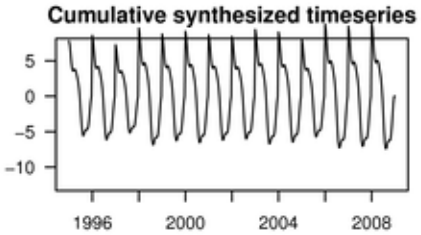

ALT smooth curve, trend removed

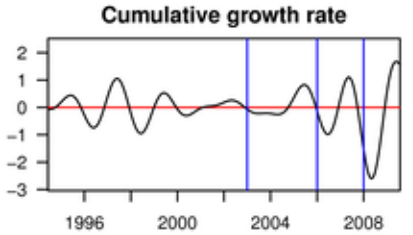

ALT smooth curve, trend removed

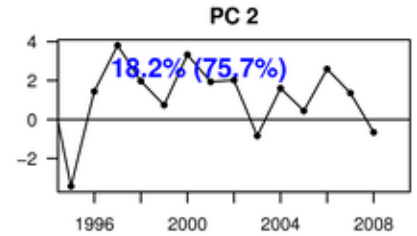

ALT IAV of growth rate

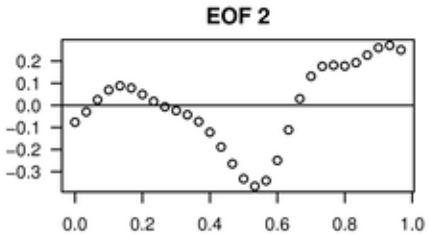

PC 1
57.5% (57.5%)

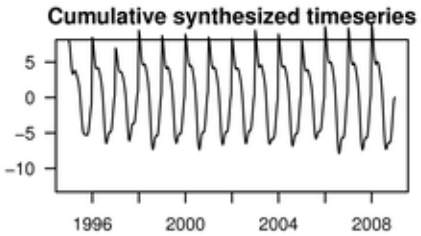

EOF 1

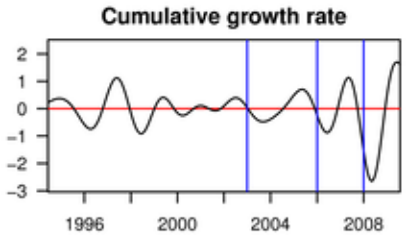

Cumulative synthesized timeseries

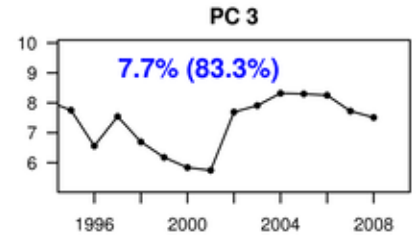

Cumulative growth rate

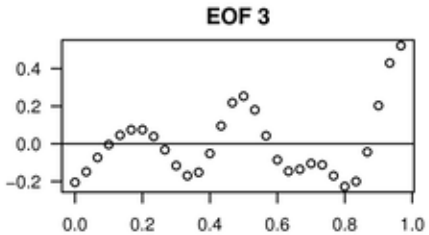

PC 2
18.2% (75.7%)

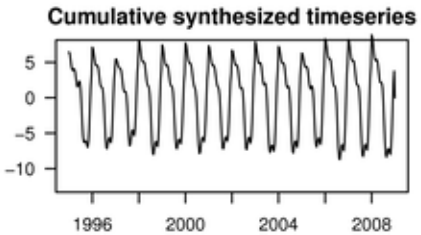

EOF 2

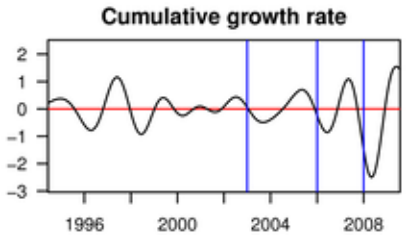

Cumulative synthesized timeseries


Cumulative growth rate


PC 3
7.7% (83.3%)


EOF 3


Cumulative synthesized timeseries


Cumulative growth rate


PC 4


EOF 4


Cumulative synthesized timeseries


Cumulative growth rate

Biennial cycle in CO_2 growth rate:

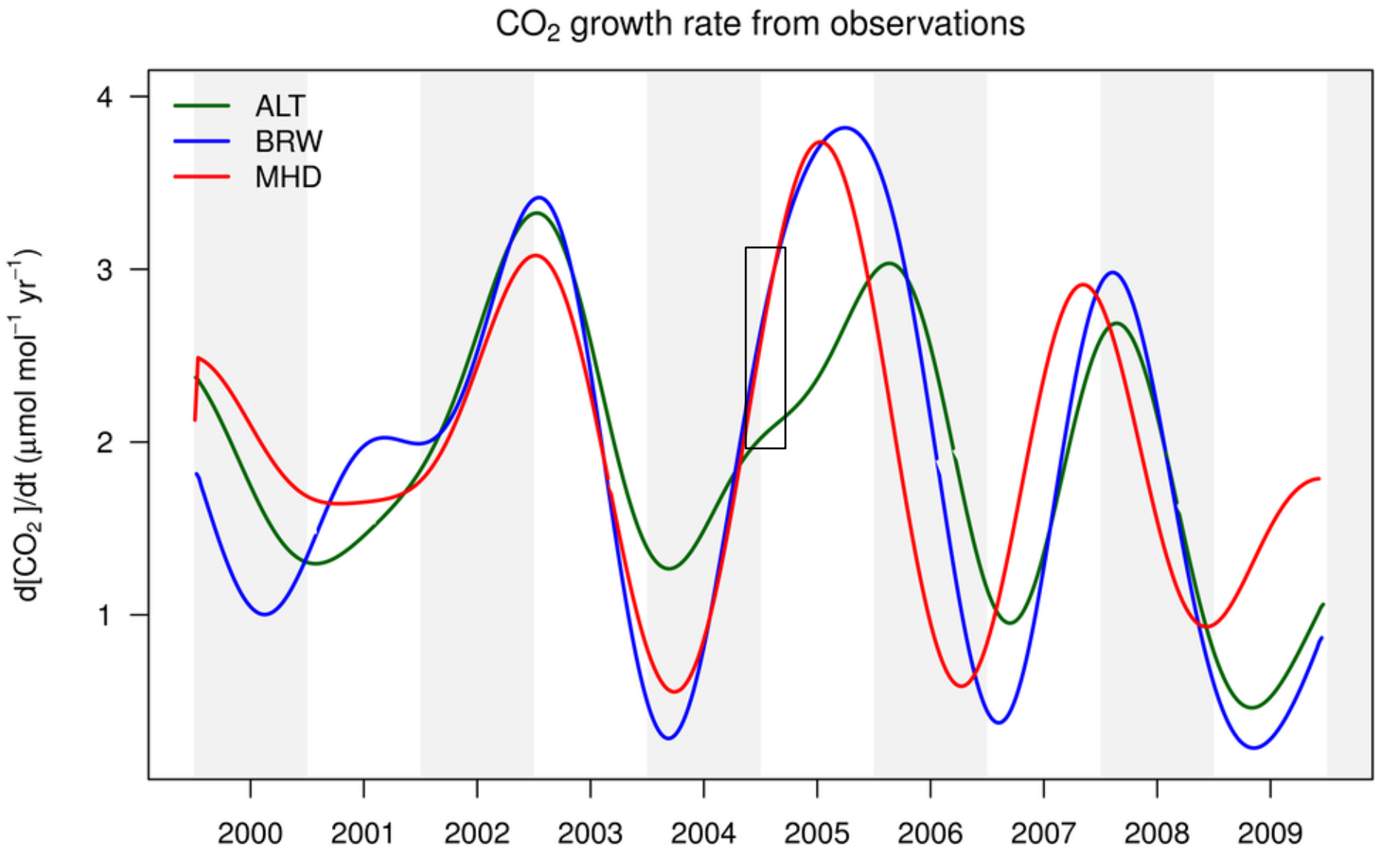
An artifact of the curve fit?

Interannual variabilty in fluxes?

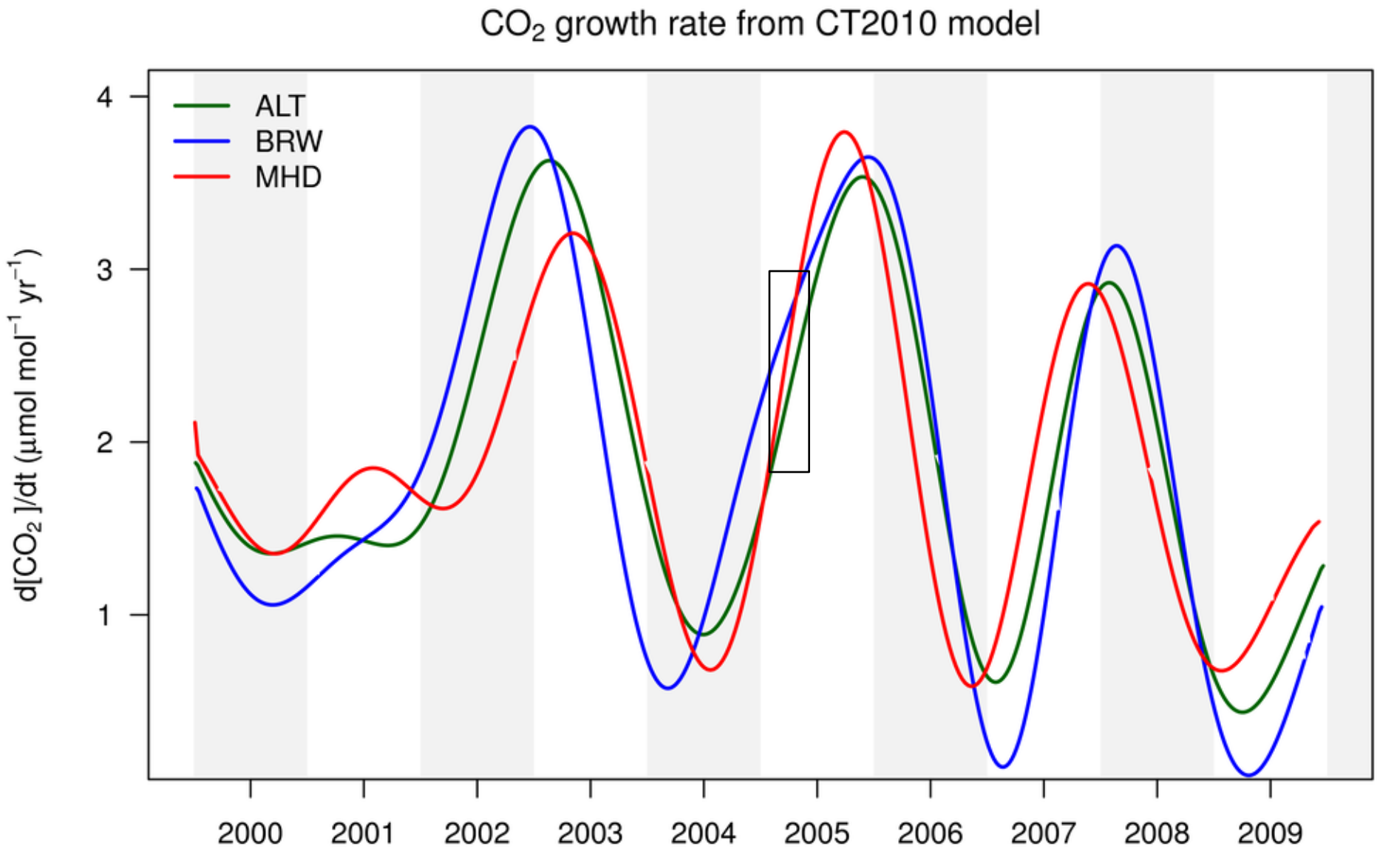
A feature of transport?

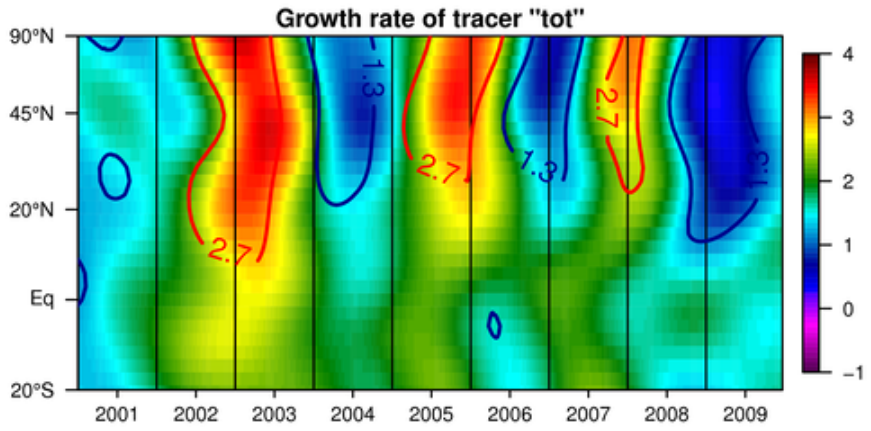
} Visible in CarbonTracker?

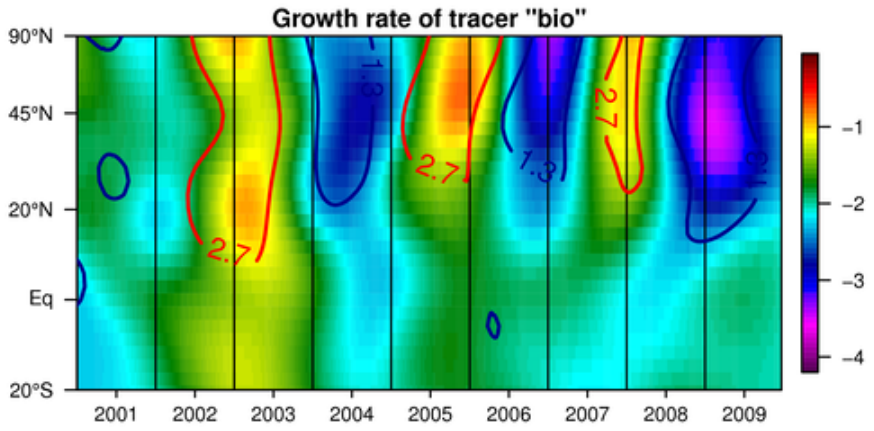
Alert missing data cause growth rate blip?

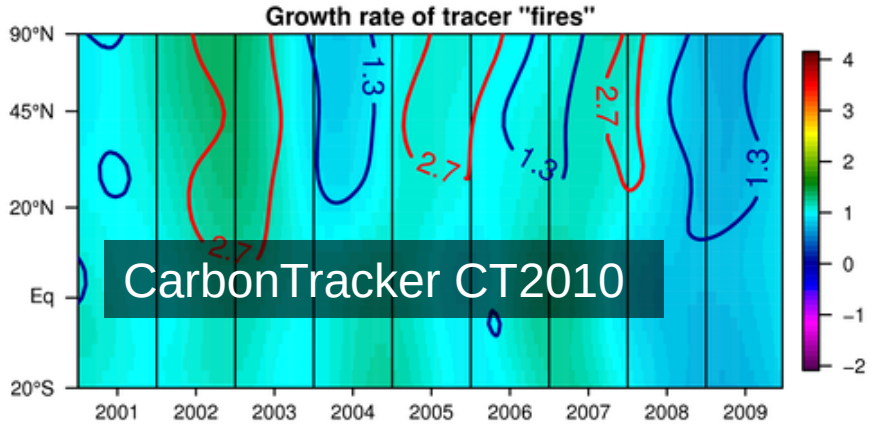


CT2010 model shows similar cycle, no blip

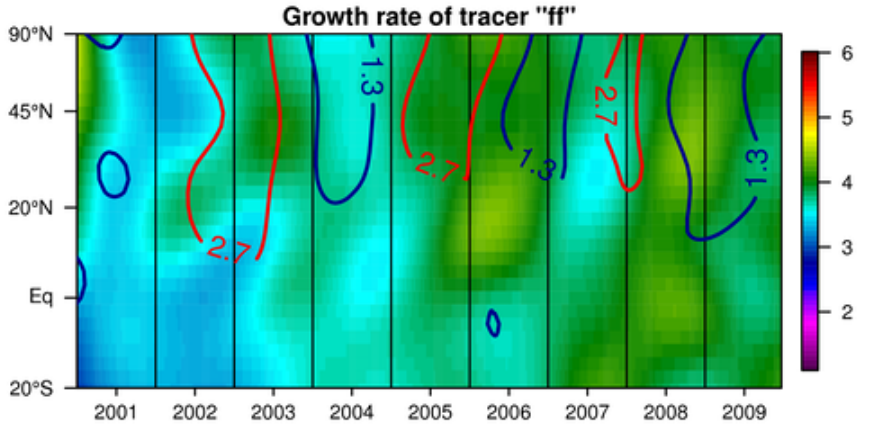


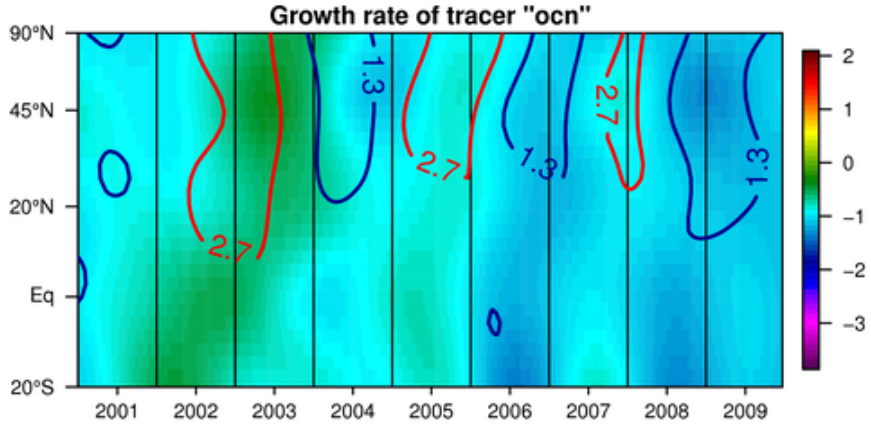


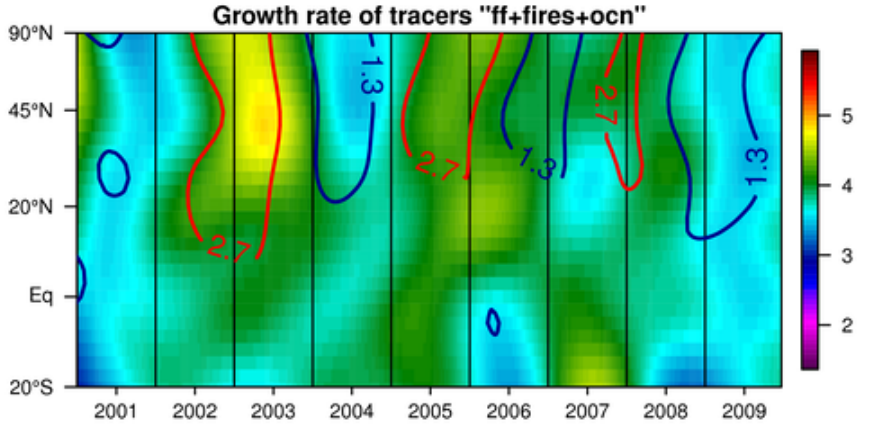


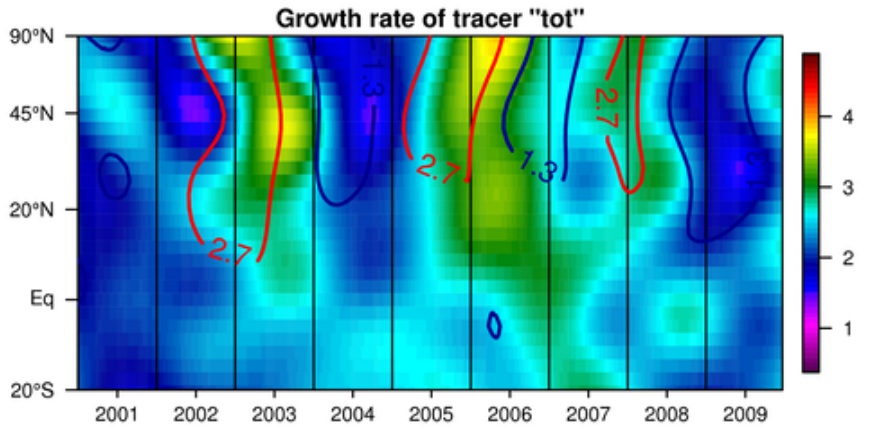


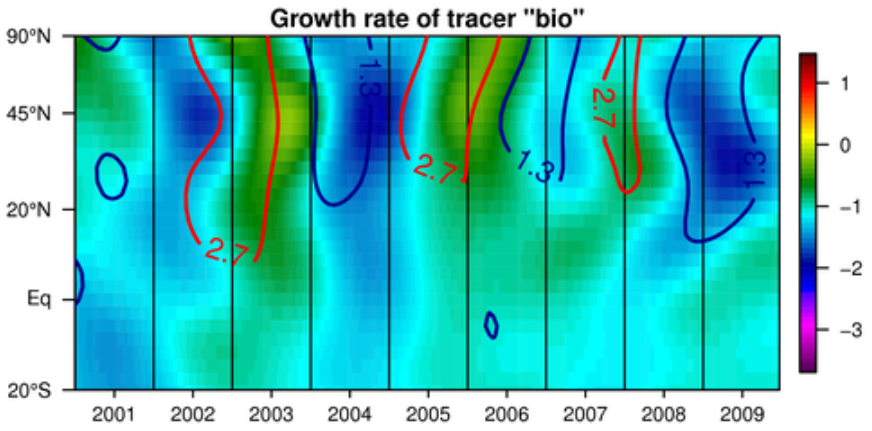
CarbonTracker CT2010

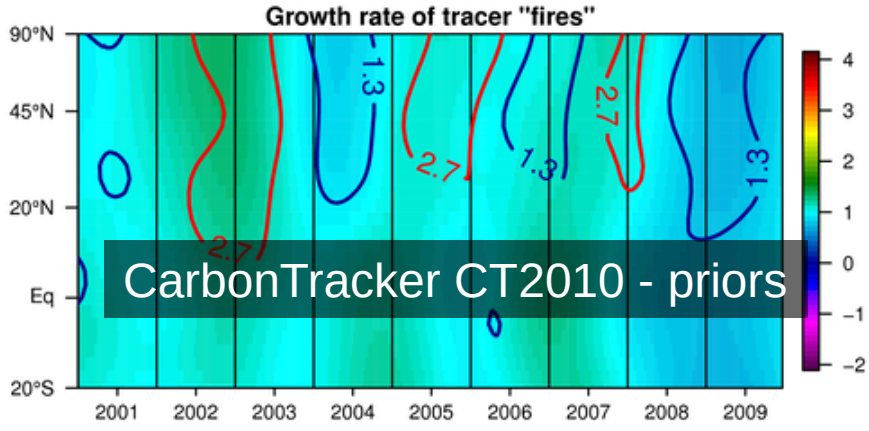


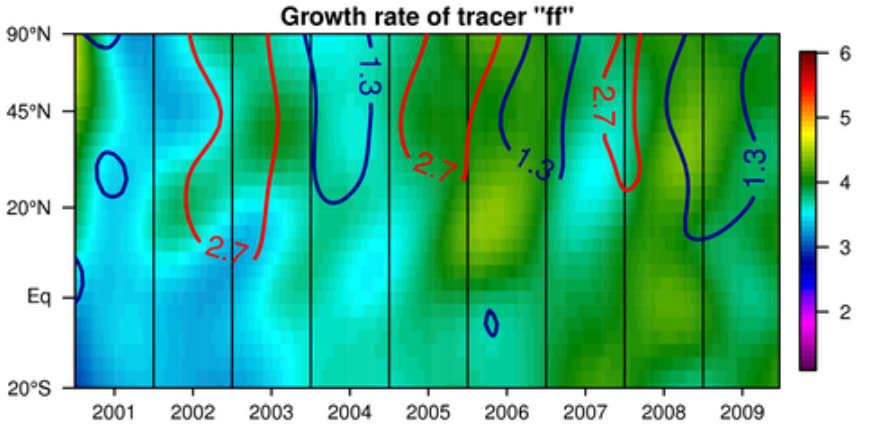




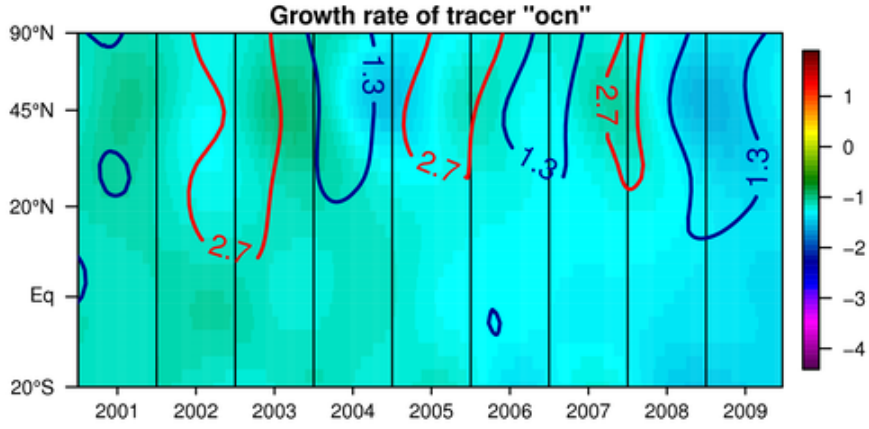


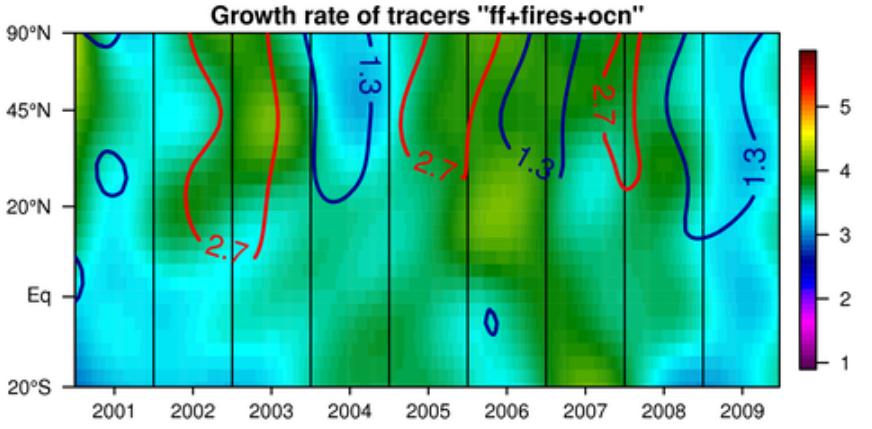


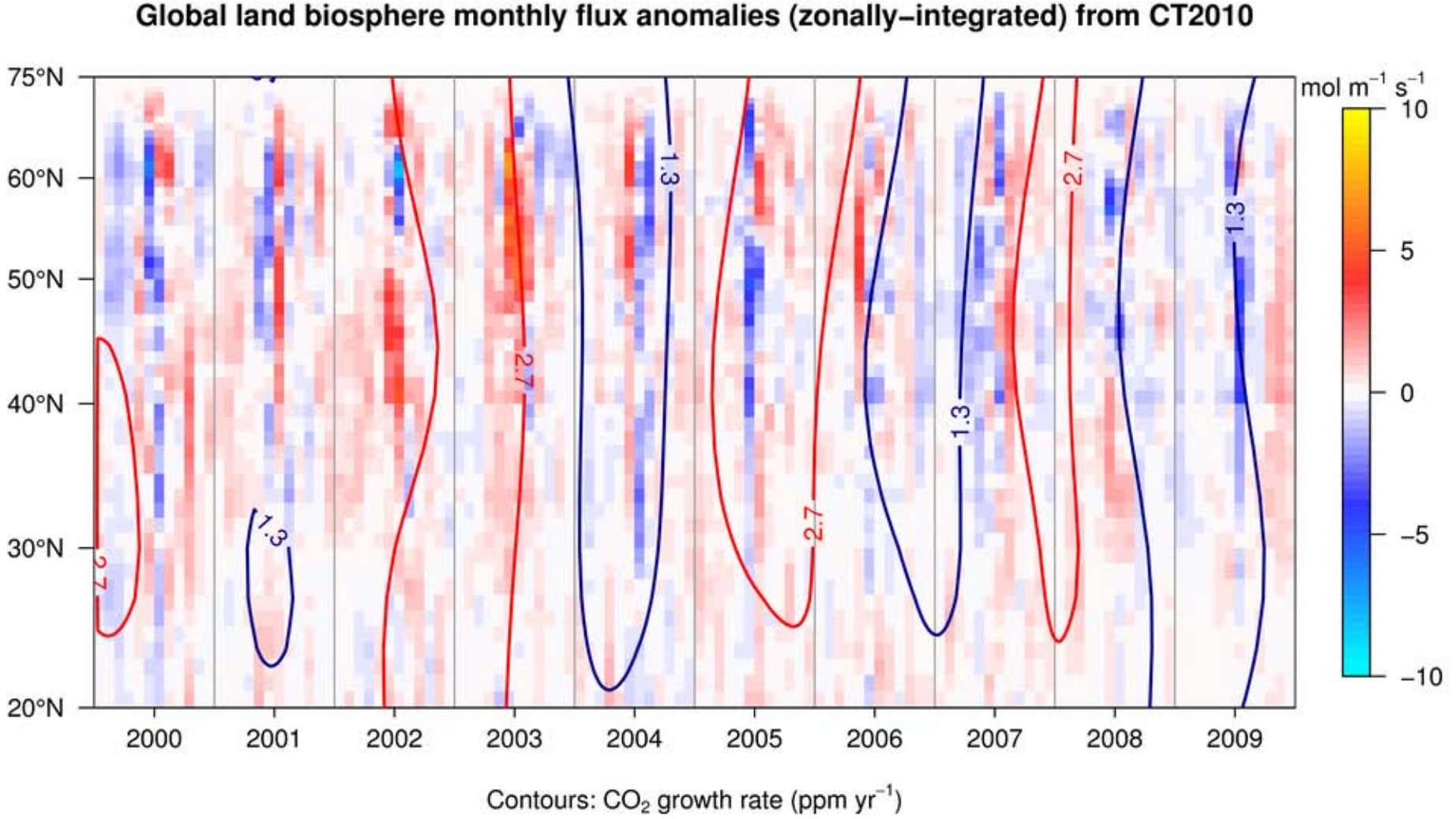




CarbonTracker CT2010 - priors






Global land biosphere monthly flux anomalies (zonally−integrated) from CT2010
75°N
60°N
50°N
40°N
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20°N
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
mol m−1 s−1
10
5
0
−5
−10
2.7
1.3
Contours: CO2 growth rate (ppm yr−1)

Biennial cycle in CO_2 growth rate:

An artifact of the curve fit? ✗

Interannual variabilty in fluxes? ✗?

A feature of transport?

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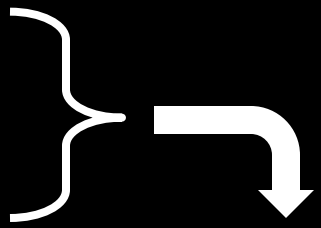
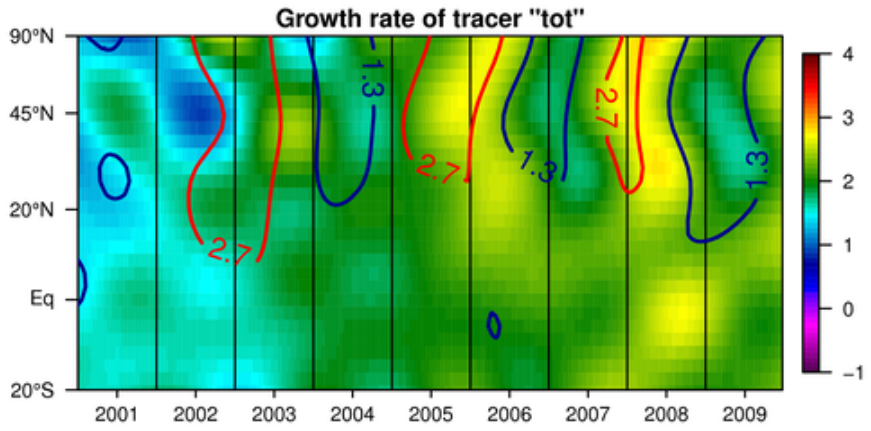


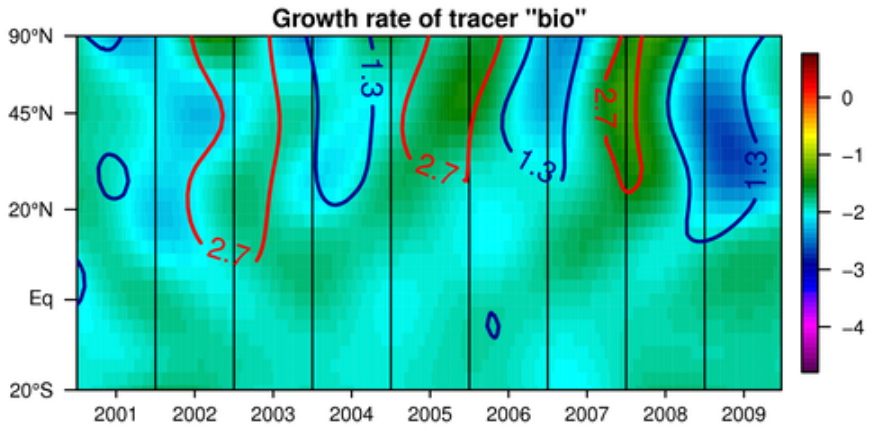
CF: "climatological fluxes"

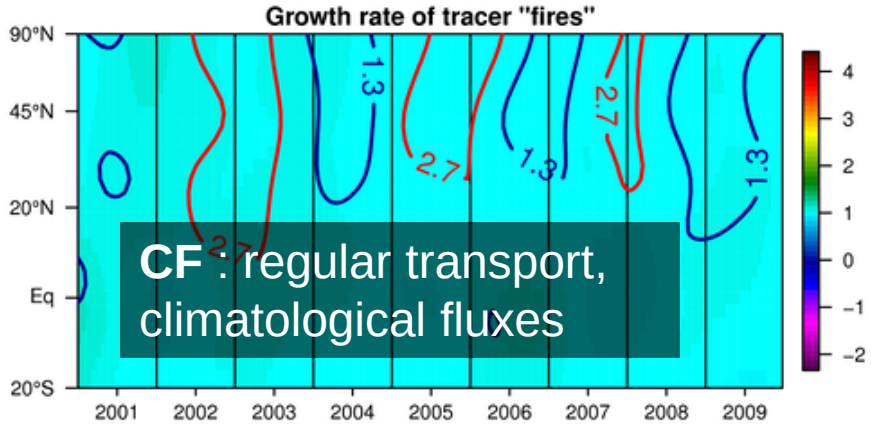
climatology of CT2010 optimized fluxes
normal, time-varying transport

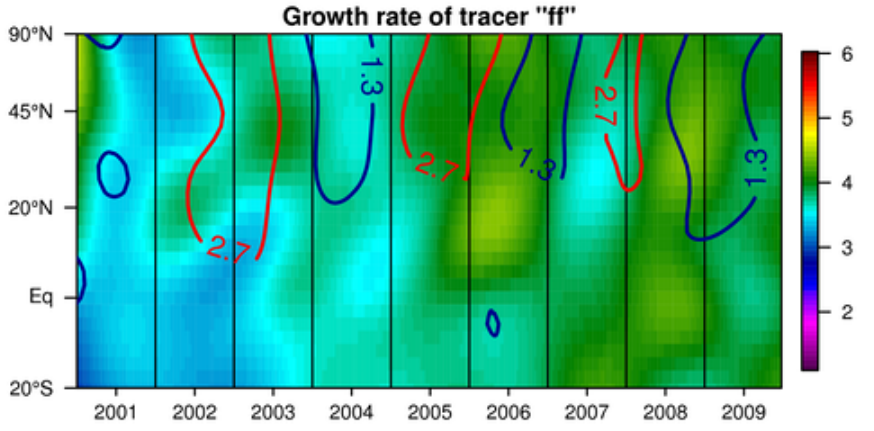
CM: "climatological meteo"

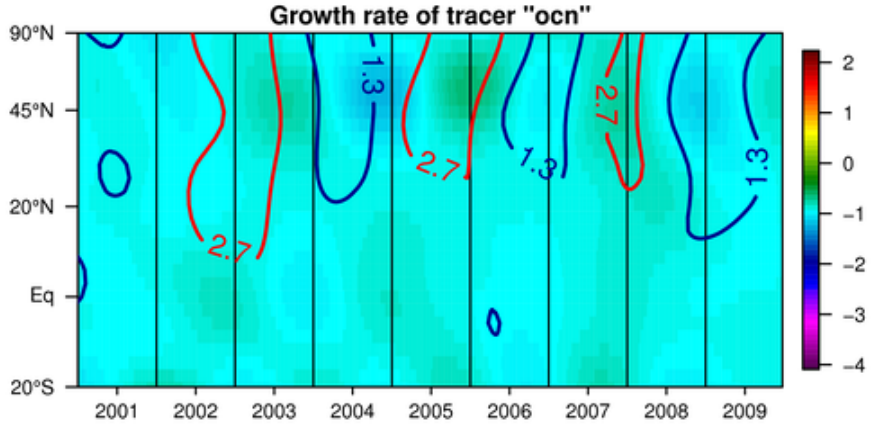
fluxes vary in time (CT2010 optimized)
transport is year 2000, repeated over and over

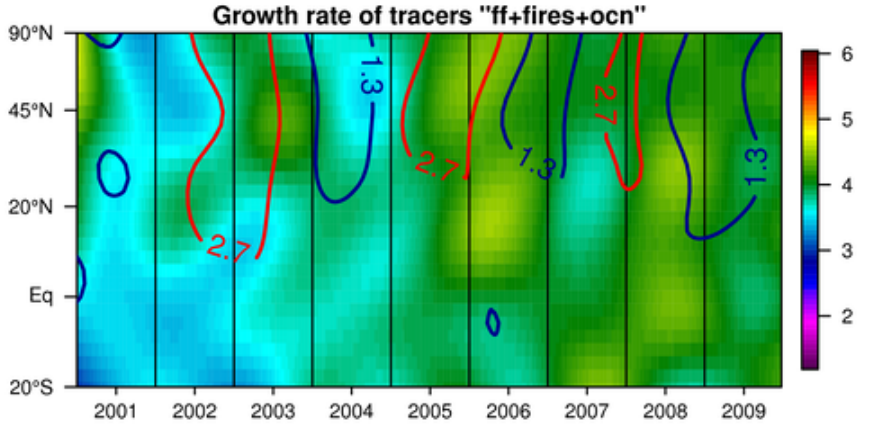




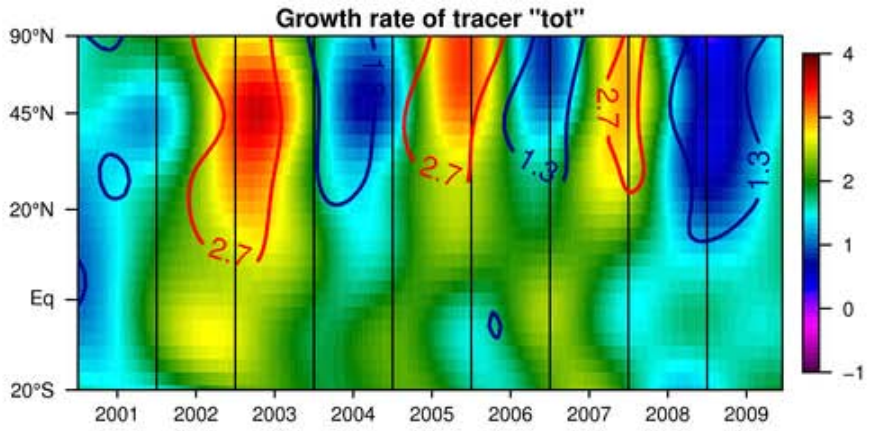


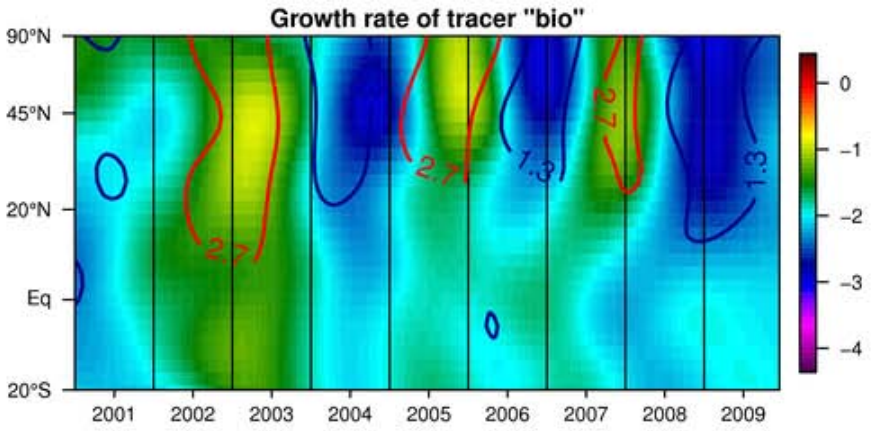


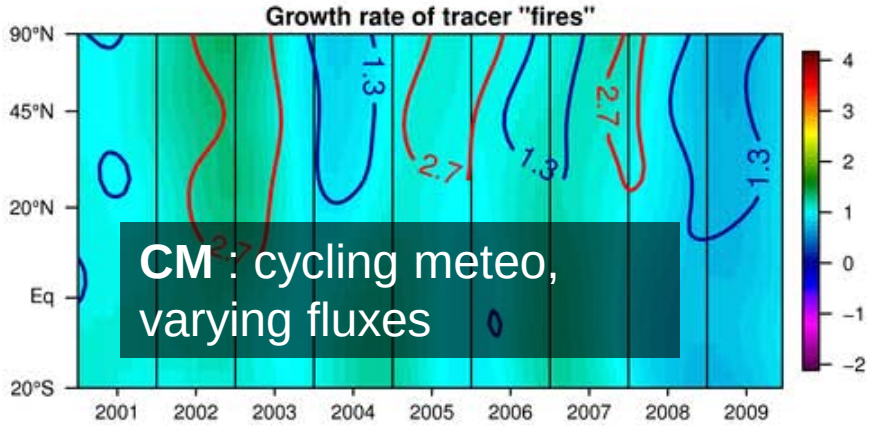


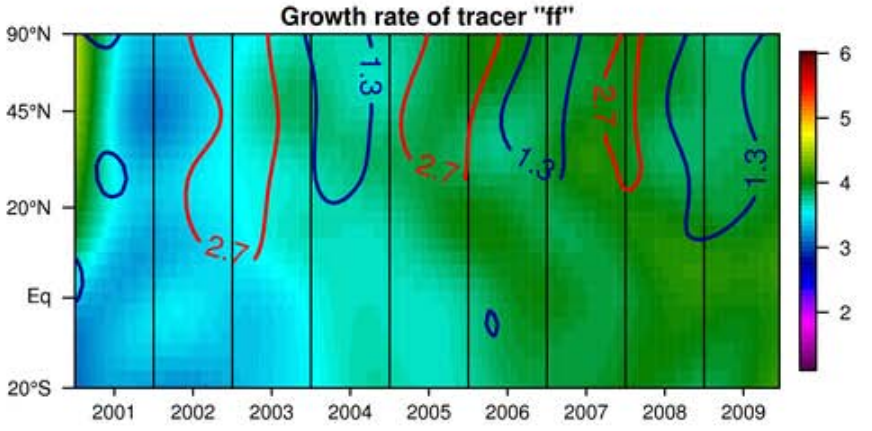


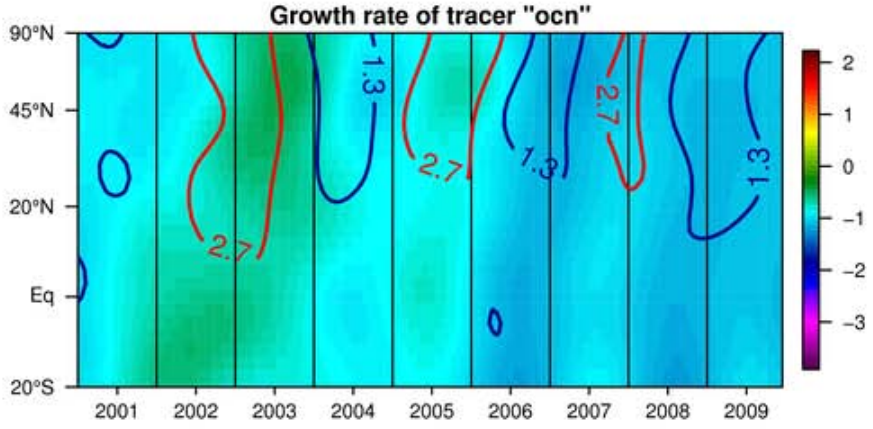
CF : regular transport, climatological fluxes

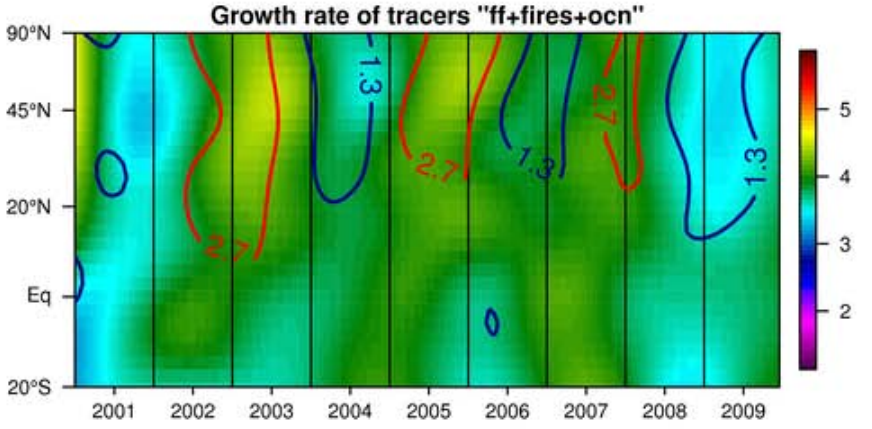




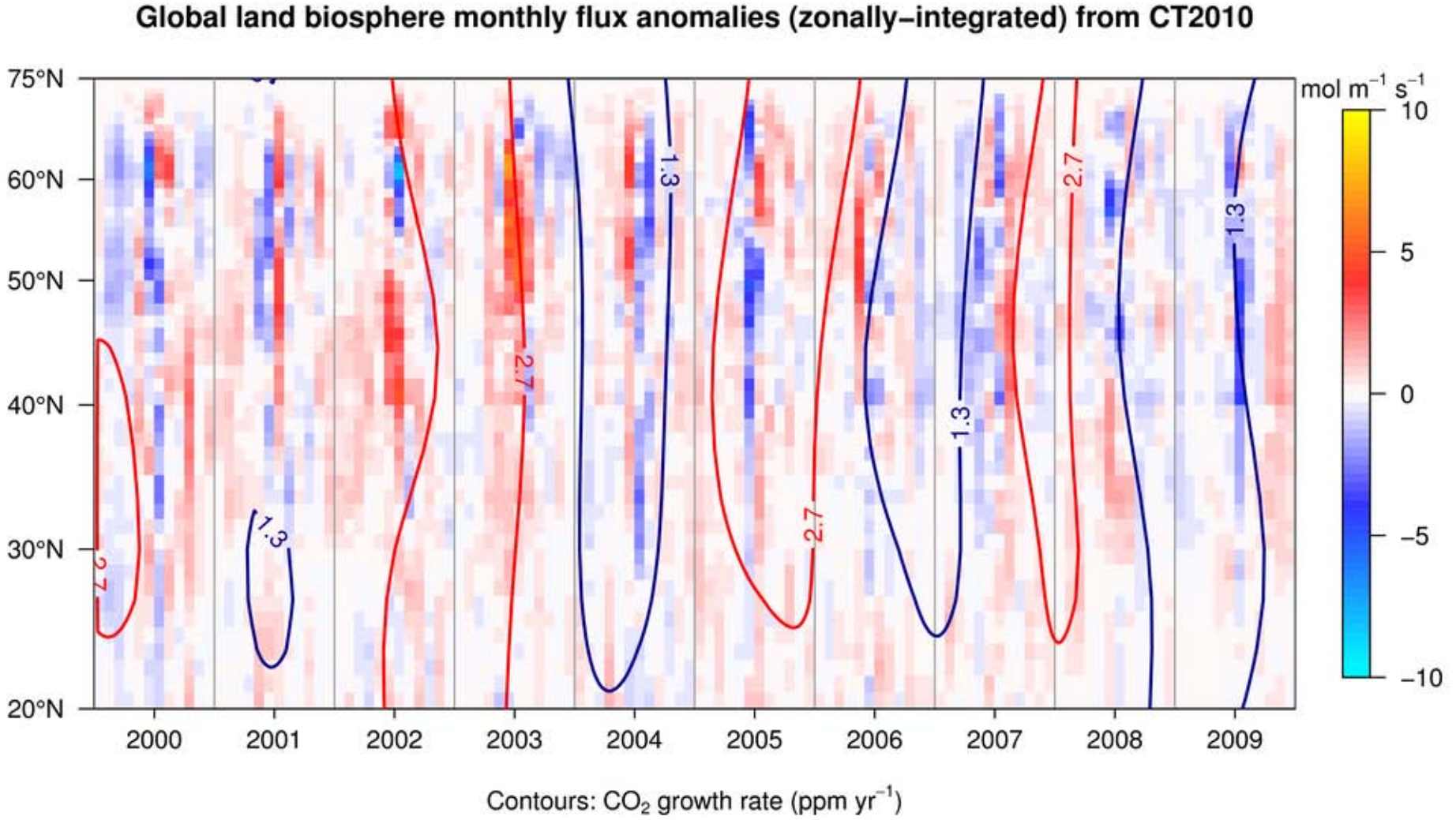








CM : cycling meteo, varying fluxes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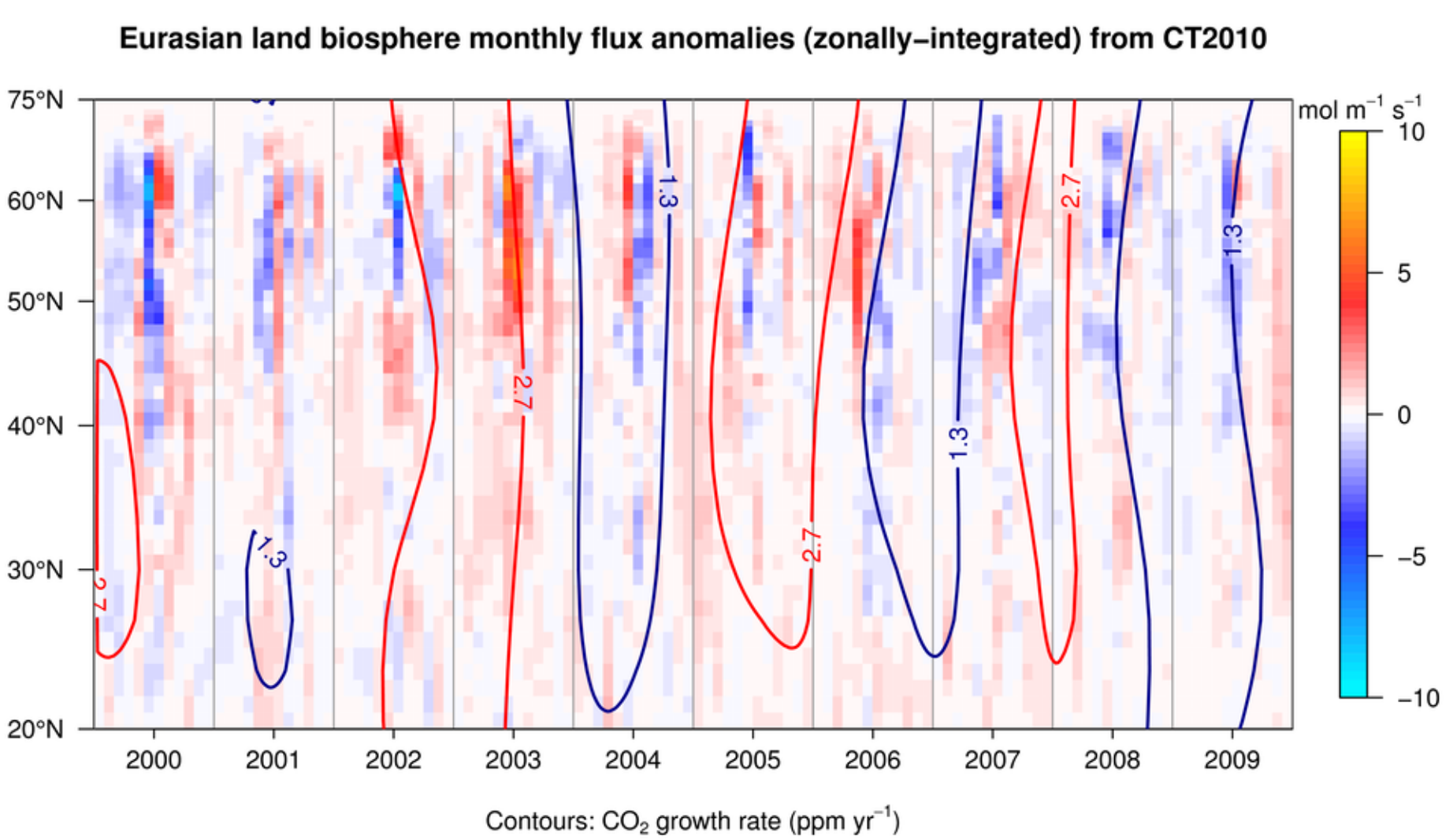
Contours: CO2 growth rate (ppm yr−1)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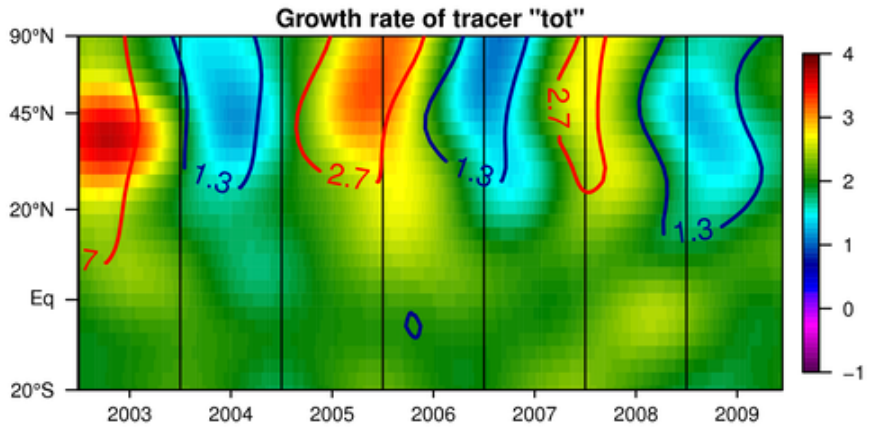
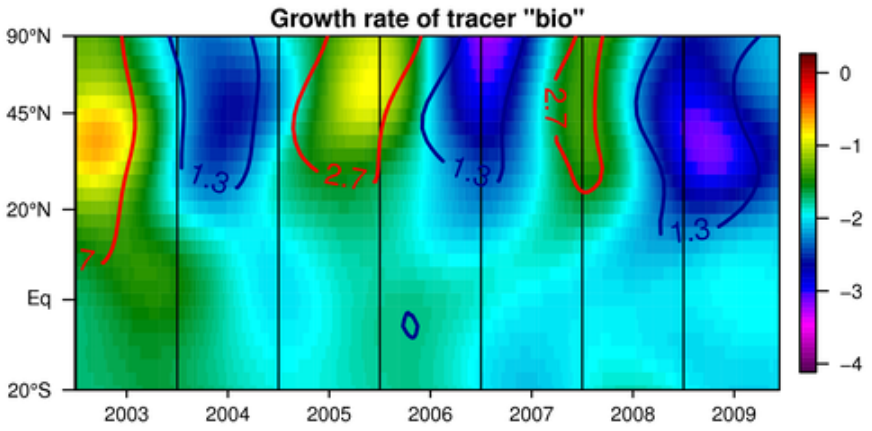
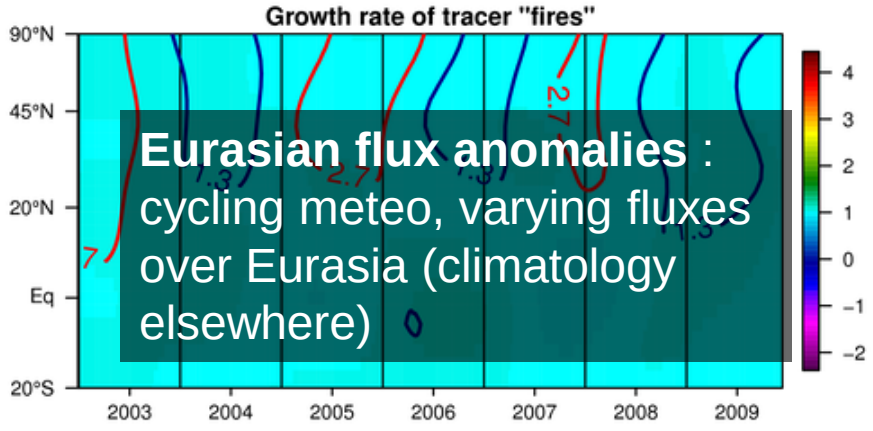
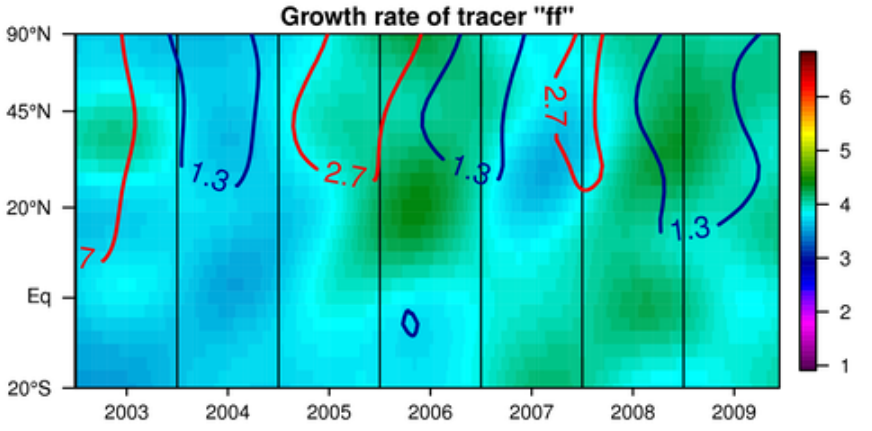
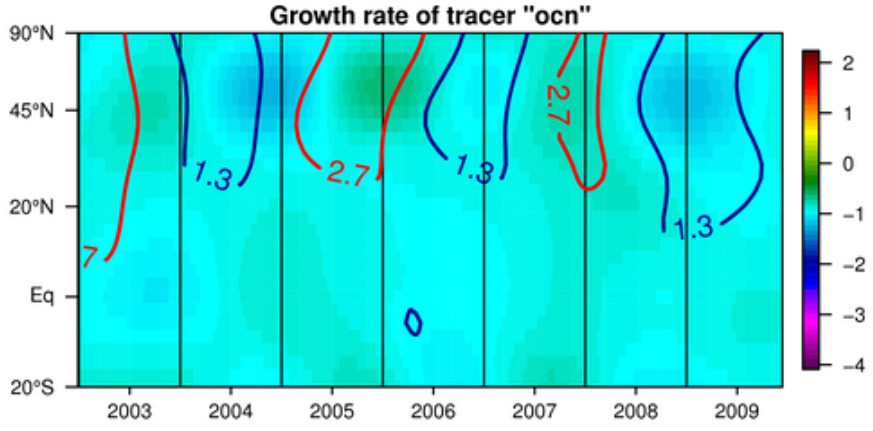
Contours: CO2 growth rate (ppm yr−1)

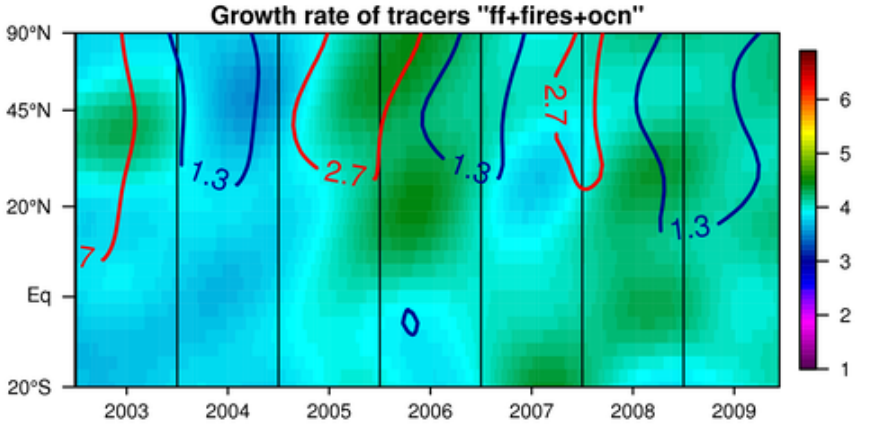




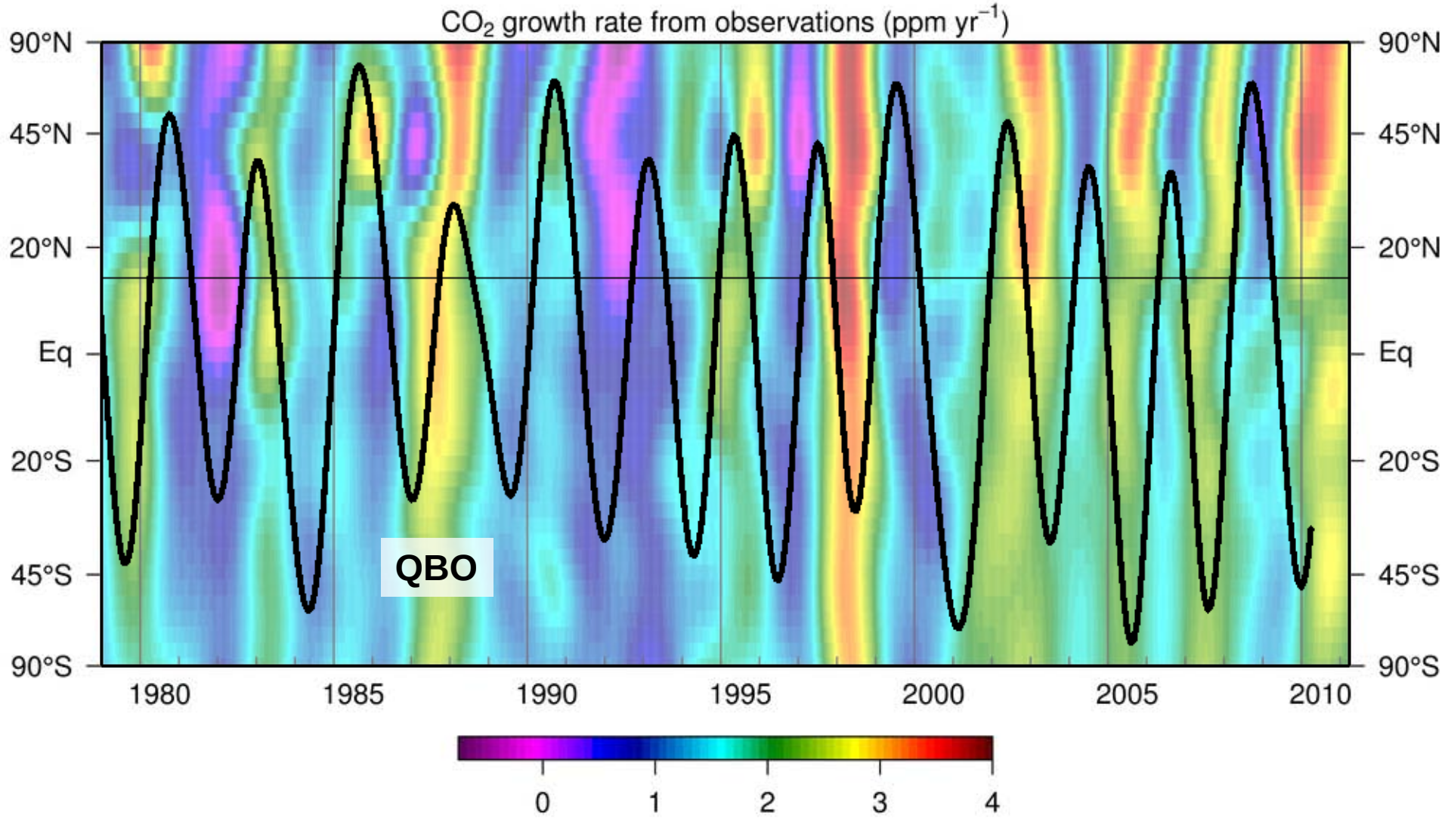


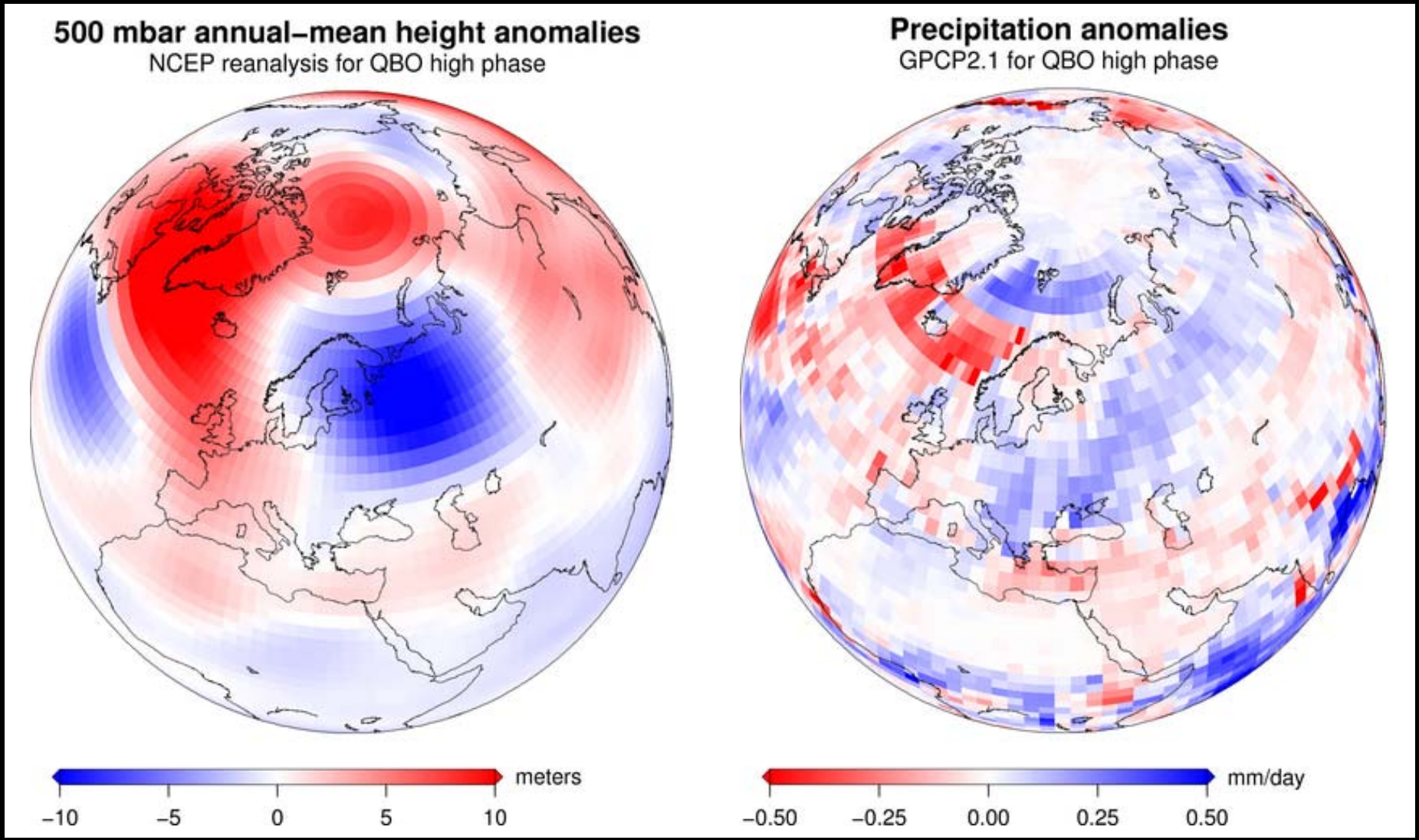






Eurasian flux anomalies : cycling meteo, varying fluxes over Eurasia (climatology elsewhere)


CO_2 growth rate from observations (ppm yr^{-1})
90°N
45°N
20°N
Eq
20°S
45°S
90°S
1980
1985
1990
1995
2000
2005
2010
QBO
0
1
2
3
4



Thanks to Gil Compo and ESRL PSD for help in this analysis.

Feature is "real"

…not an artifact of curve fitting

…not due to changes in shape of seasonal cycle

Feature can be seen in CarbonTracker

…attributed to the land biosphere

…suggested also by prior land model fluxes

Feature is mainly due to land flux variability

…but has a transport component

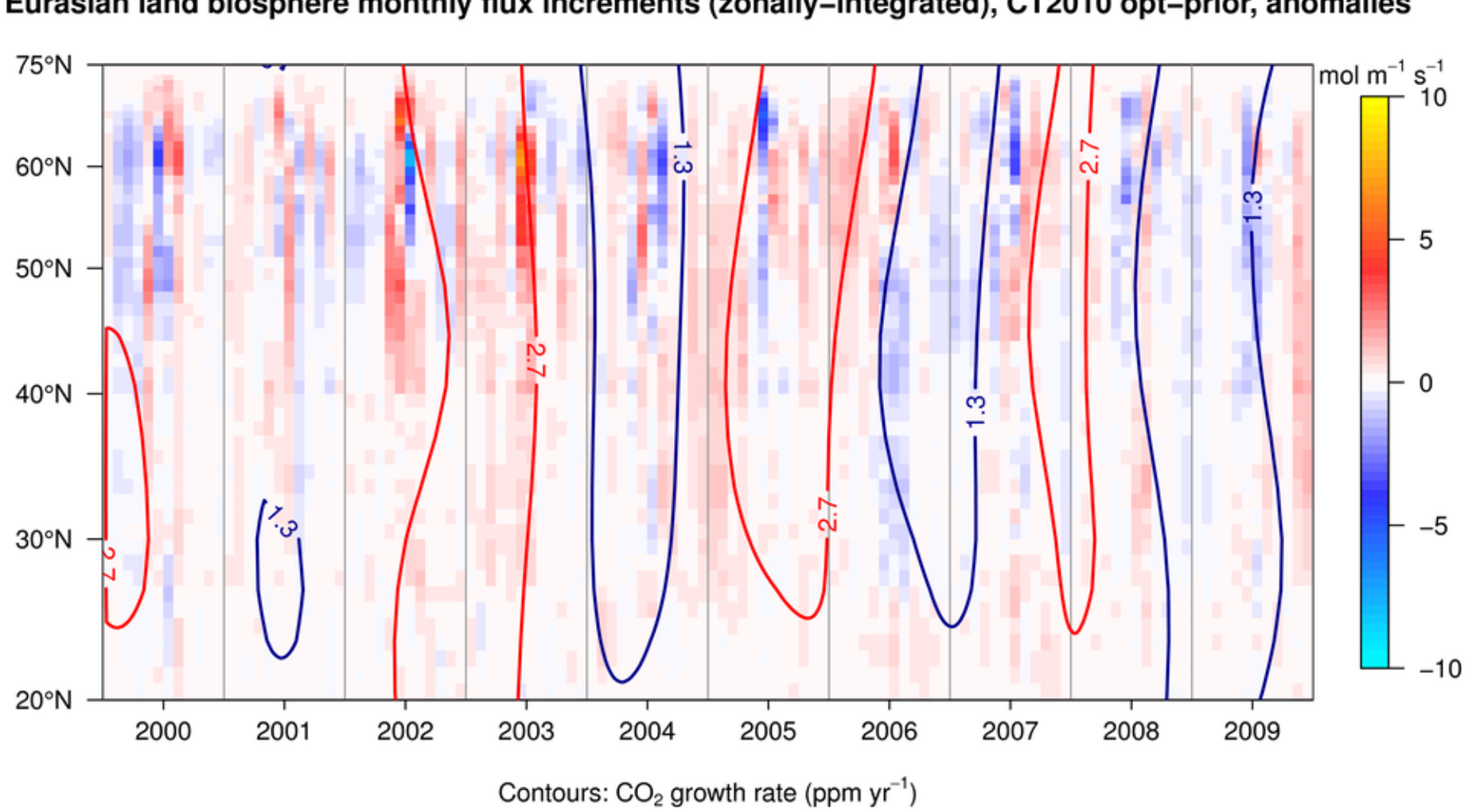
…work is ongoing

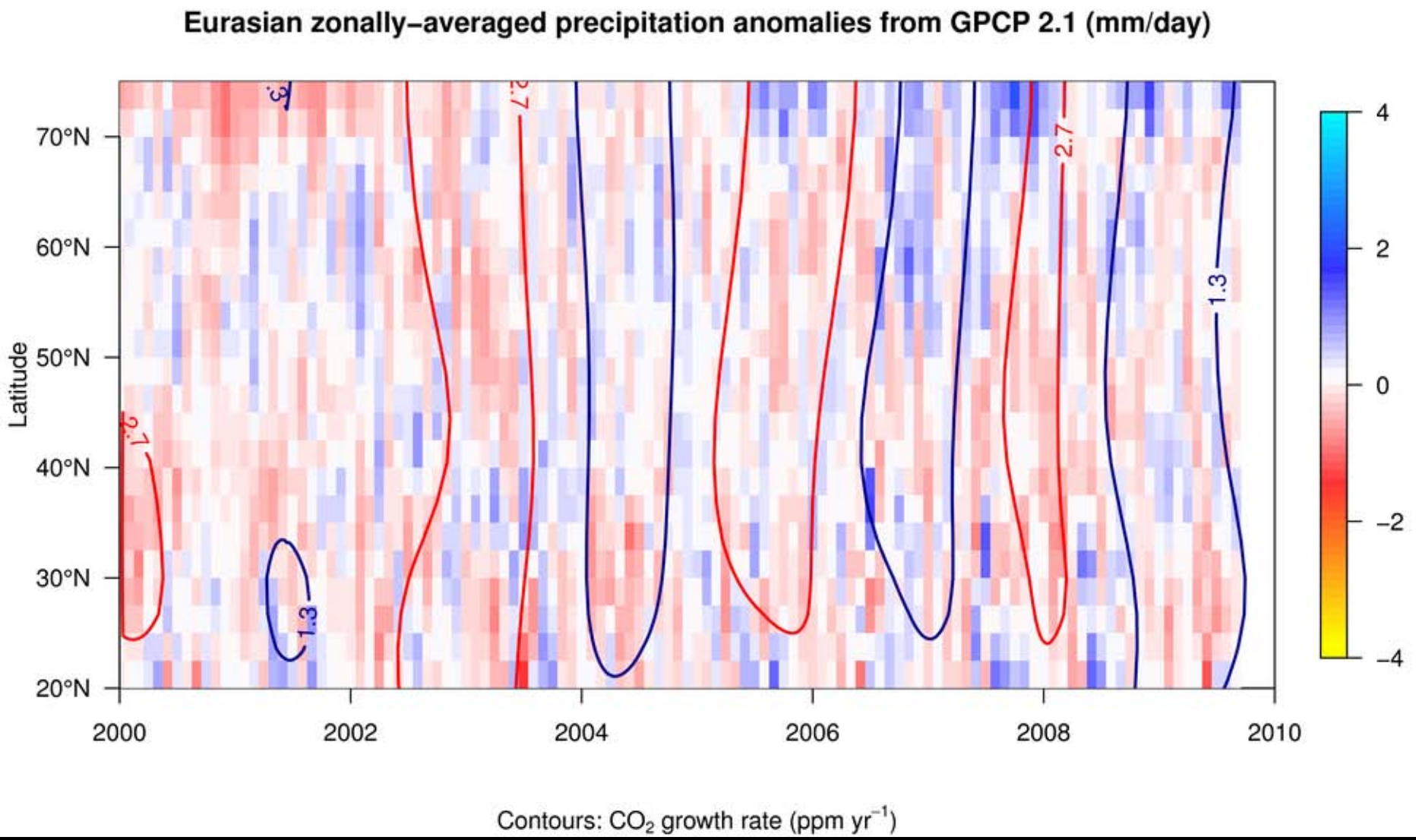
No obvious relationship between flux anomalies and growth rate feature

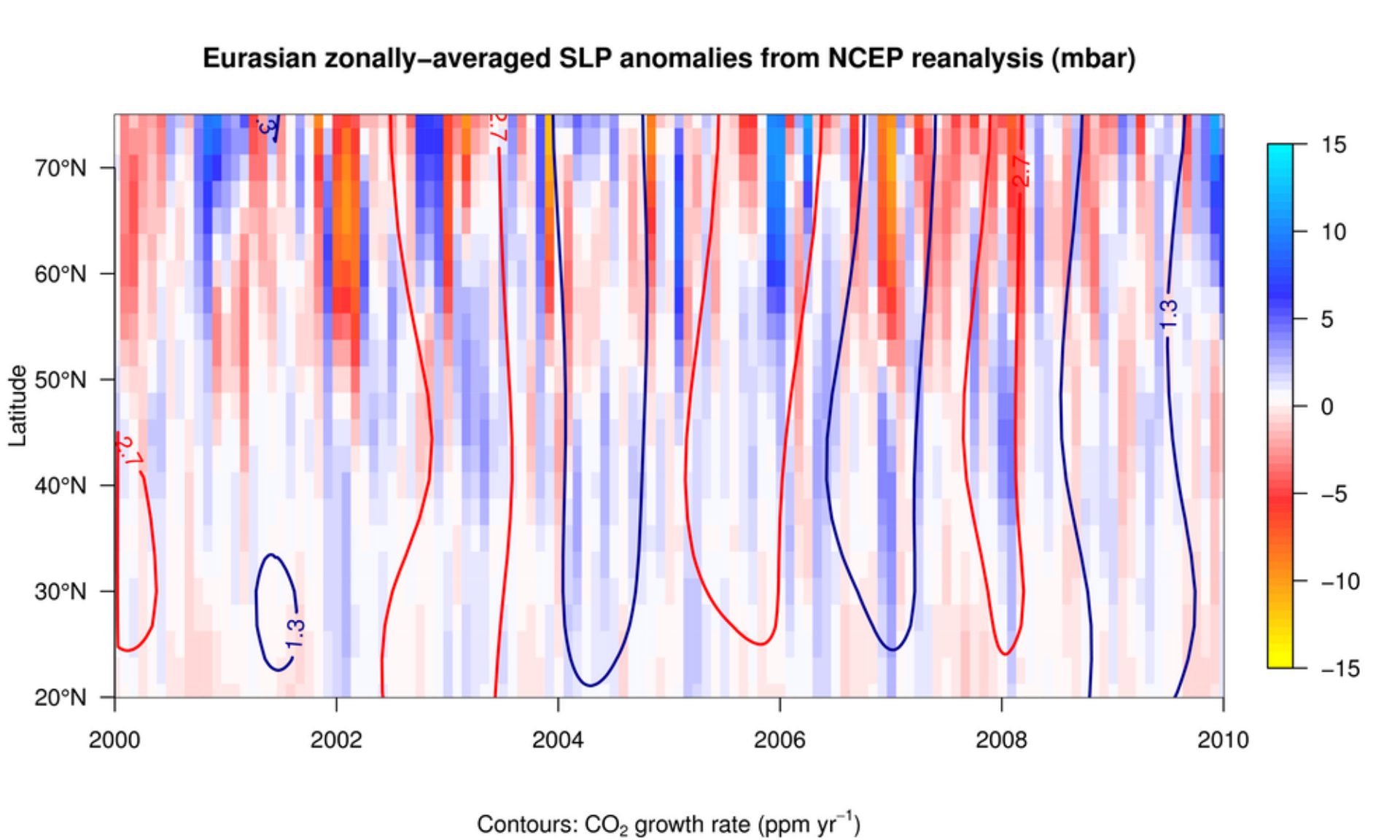
…no correlations with precip & temperature anomalies

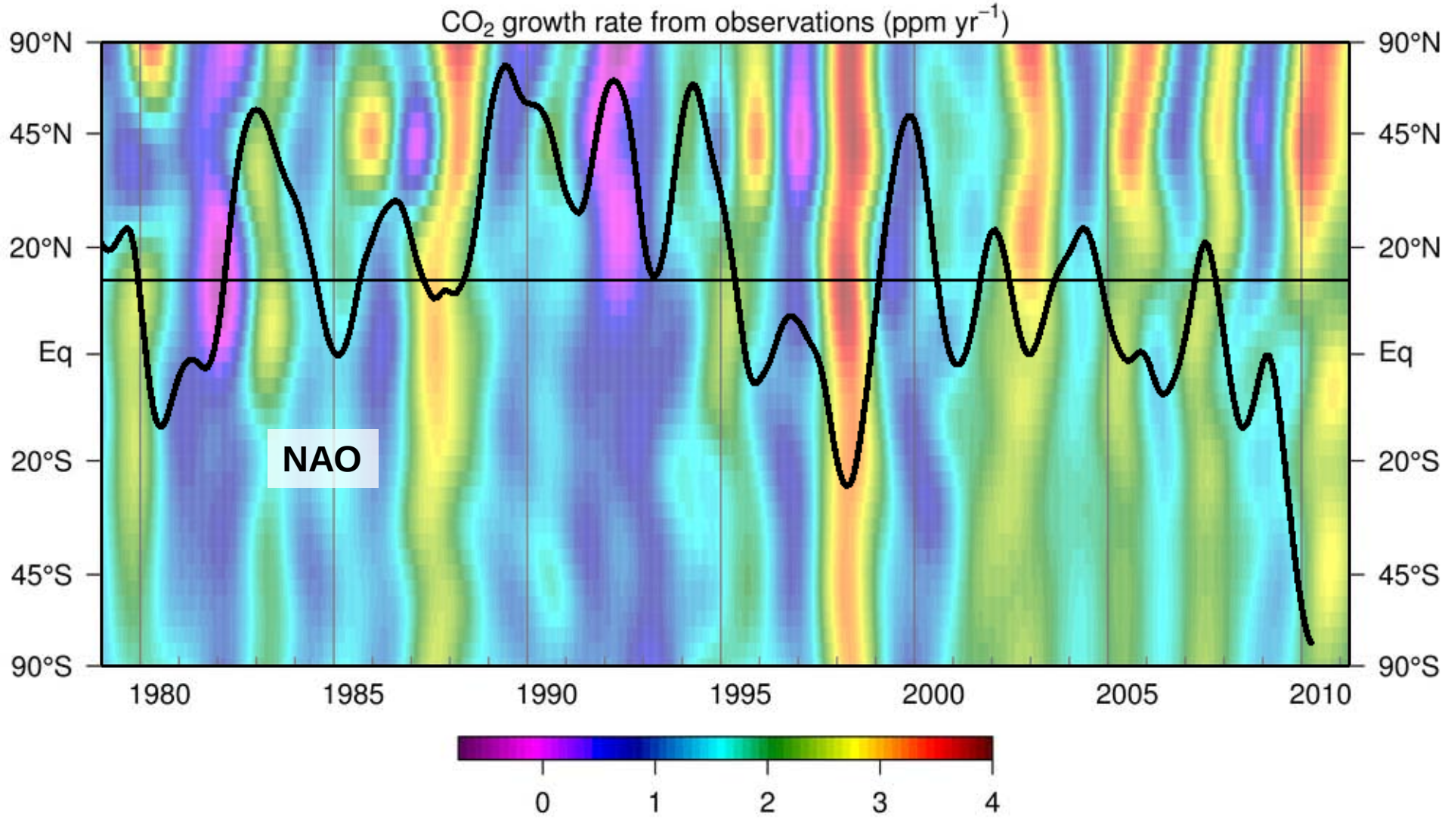
…where? suggstions of Eurasia

…when? Must have a seasonal component


Eurasian land biosphere monthly flux increments (zonally−integrated), CT2010 opt−prior, anomalies
75°N
60°N
50°N
40°N
30°N
20°N
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
mol m⁻¹ s⁻¹
10
5
0
−5
−10
2.7
1.3
Contours: CO2 growth rate (ppm yr−1)


Eurasian zonally−averaged precipitation anomalies from GPCP 2.1 (mm/day)
70°N
60°N
50°N
40°N
30°N
20°N
Latitude
2000
2002
2004
2006
2008
2010
2.7
1.3
4
2
0
−2
−4
Contours: CO2 growth rate (ppm yr−1)


Eurasian zonally−averaged SLP anomalies from NCEP reanalysis (mbar)
70°N
60°N
50°N
40°N
30°N
20°N
Latitude
2000
2002
2004
2006
2008
2010
2.7
2.7
2.7
1.3
1.3
1.3
15
10
5
0
−5
−10
−15
Contours: CO2 growth rate (ppm yr−1)


CO_2 growth rate from observations (ppm yr^{-1})
90°N
45°N
20°N
Eq
20°S
45°S
90°S
1980
1985
1990
1995
2000
2005
2010
NAO
0
1
2
3
4