Attribution of CO_2 seasonal cycle amplification in Northern Hemisphere: Analyses based on a tagged CO_2 transport model

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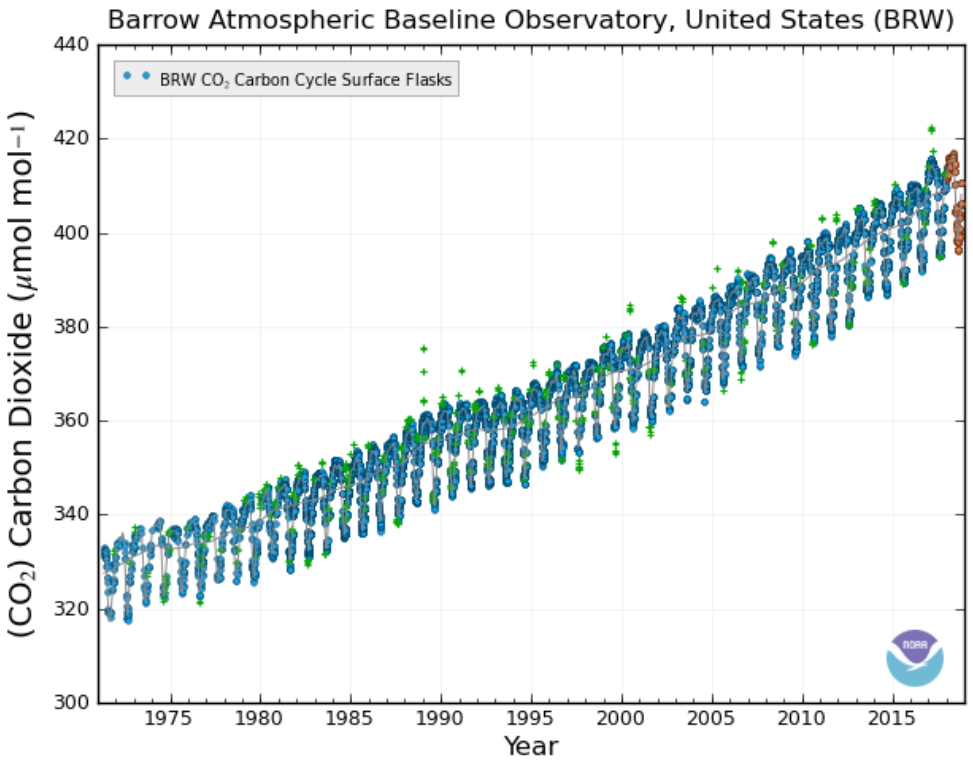
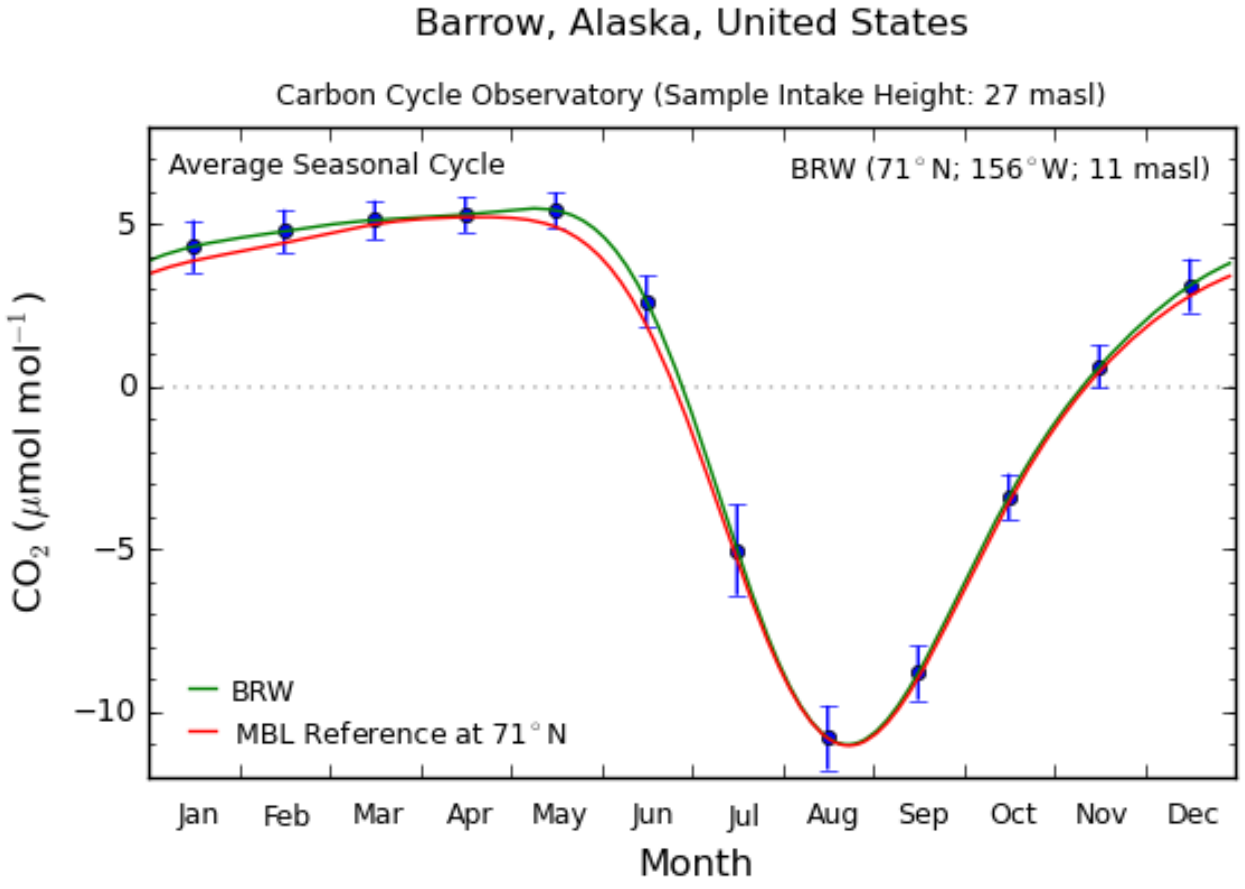
University of Michigan

CESM Workshop, Boulder
Feb. 13, 2019

CO_2 seasonal cycle as one of key indicators of carbon balance





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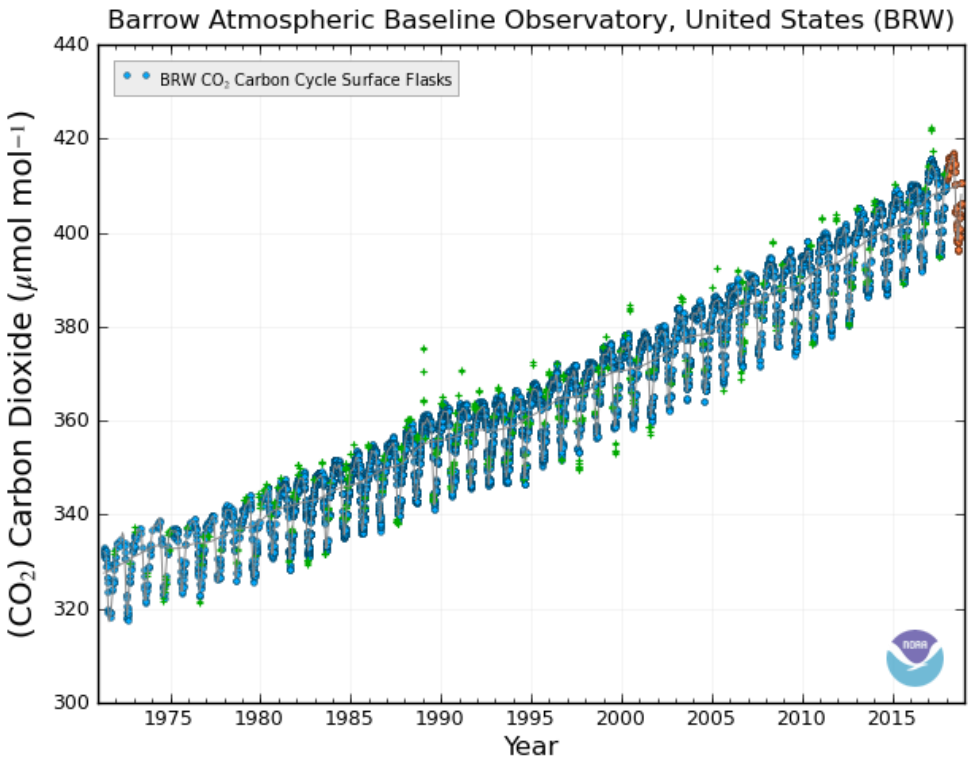

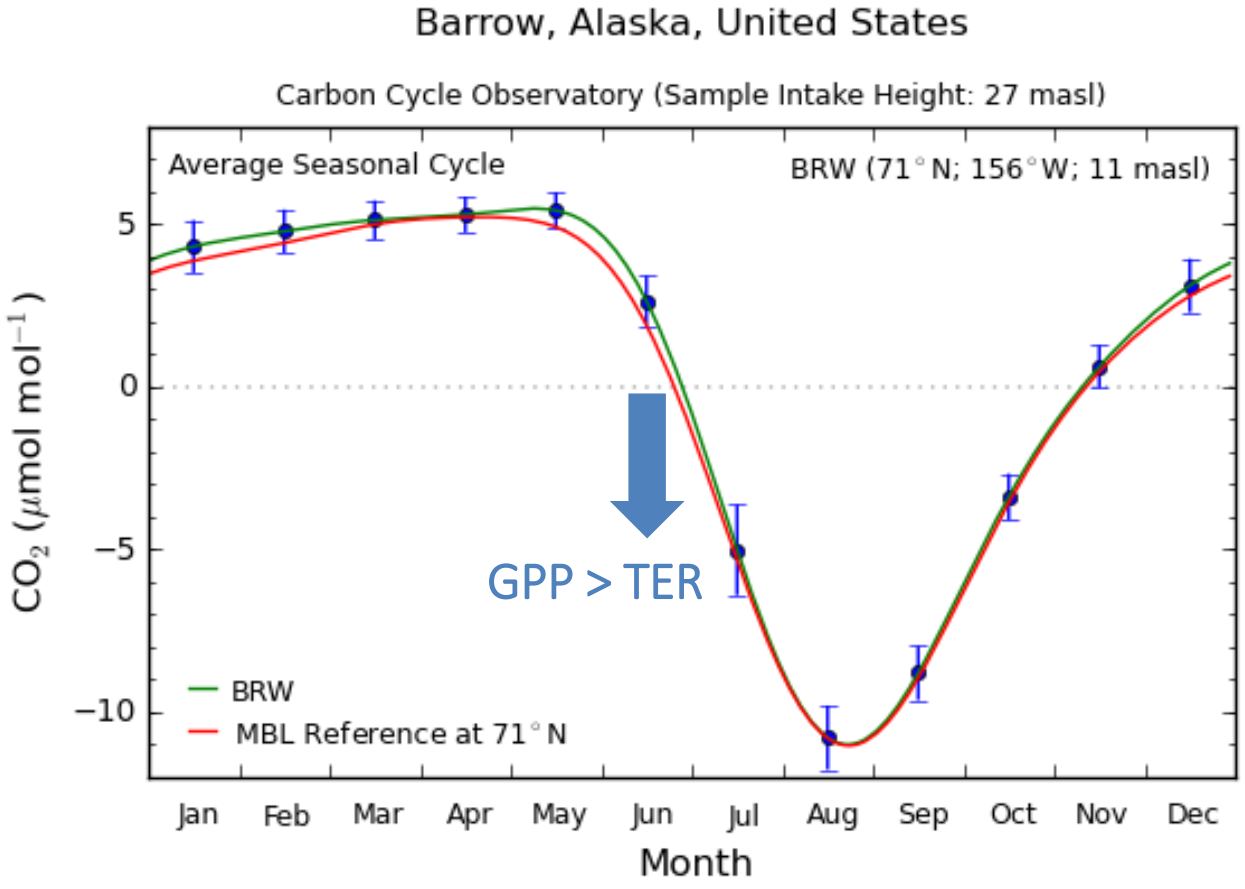

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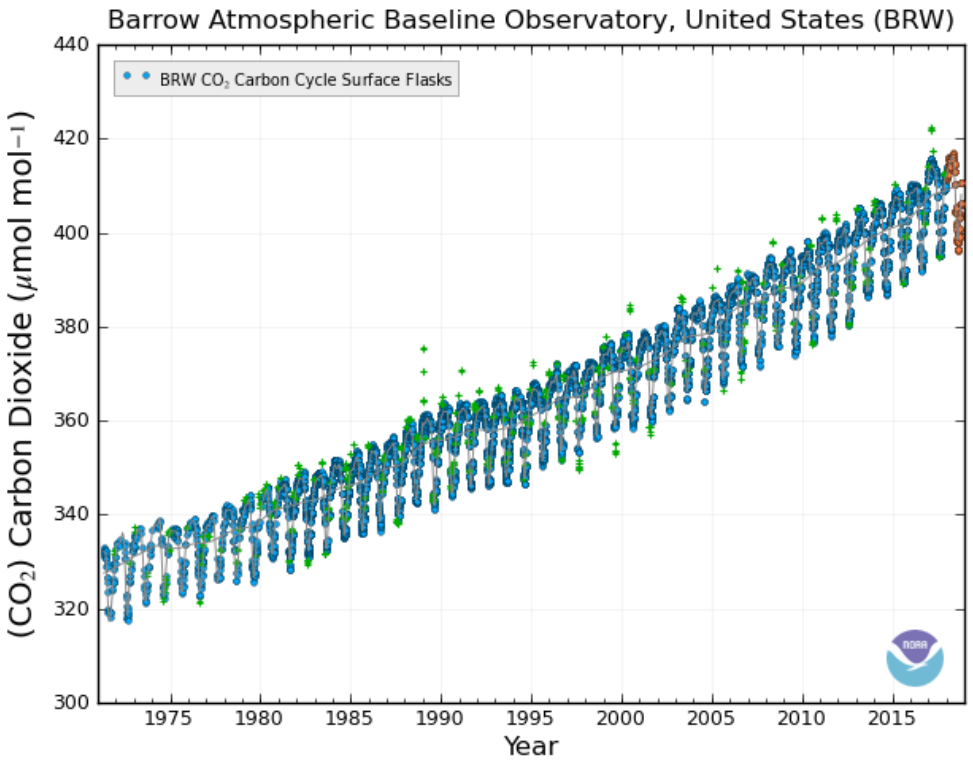

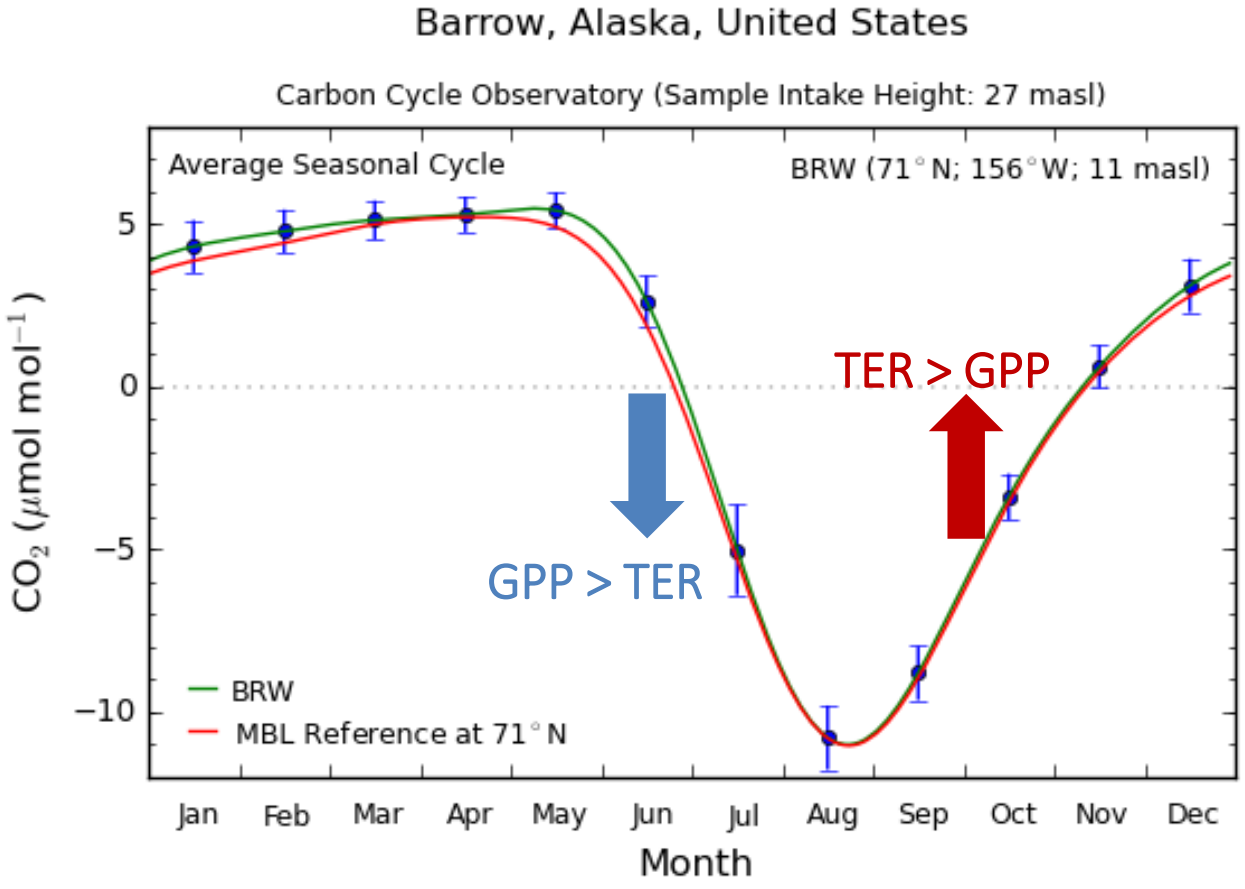

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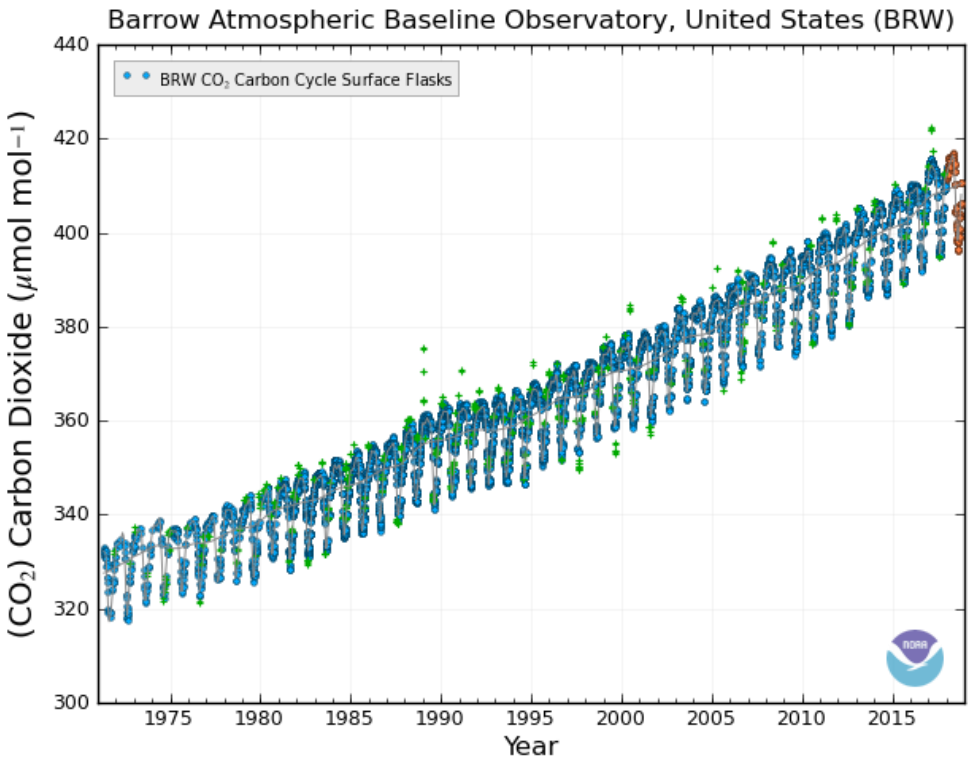
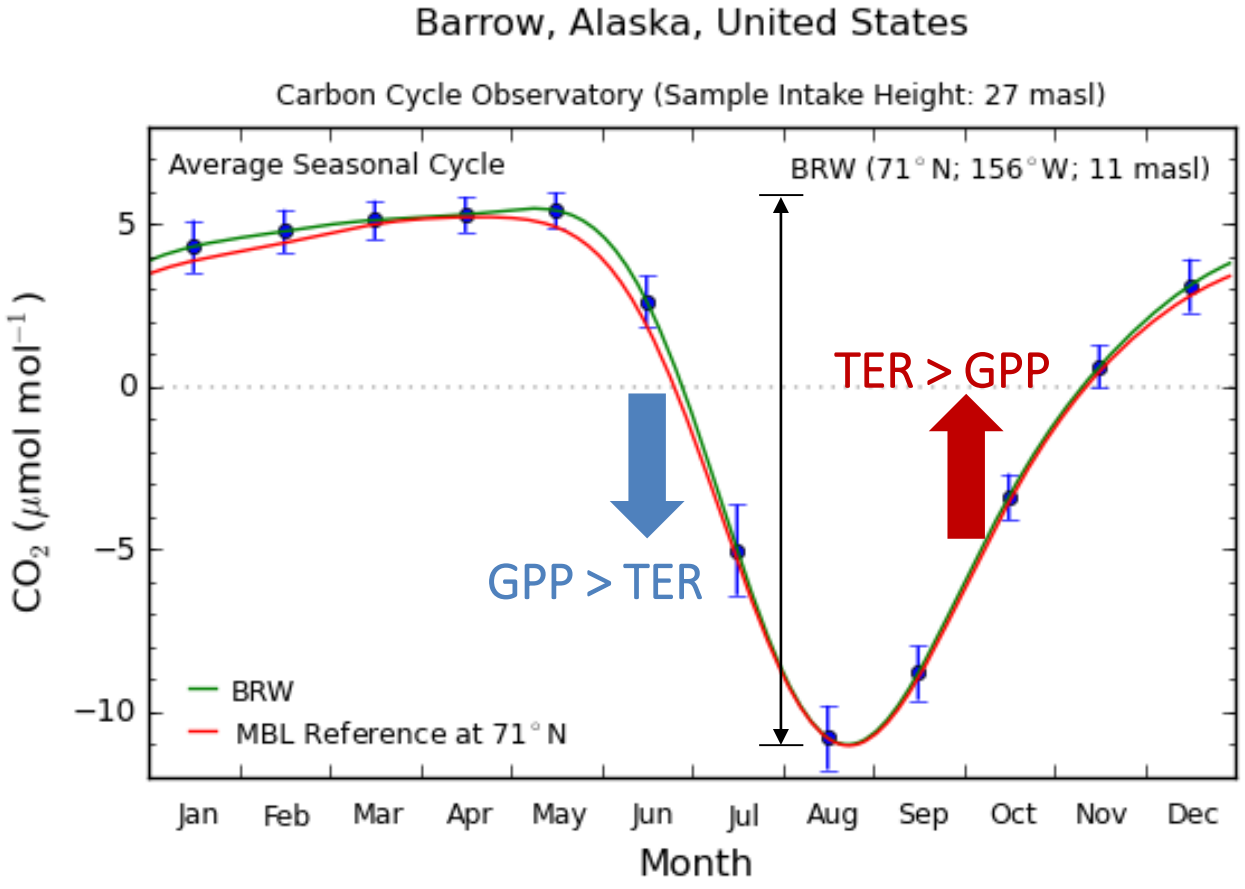
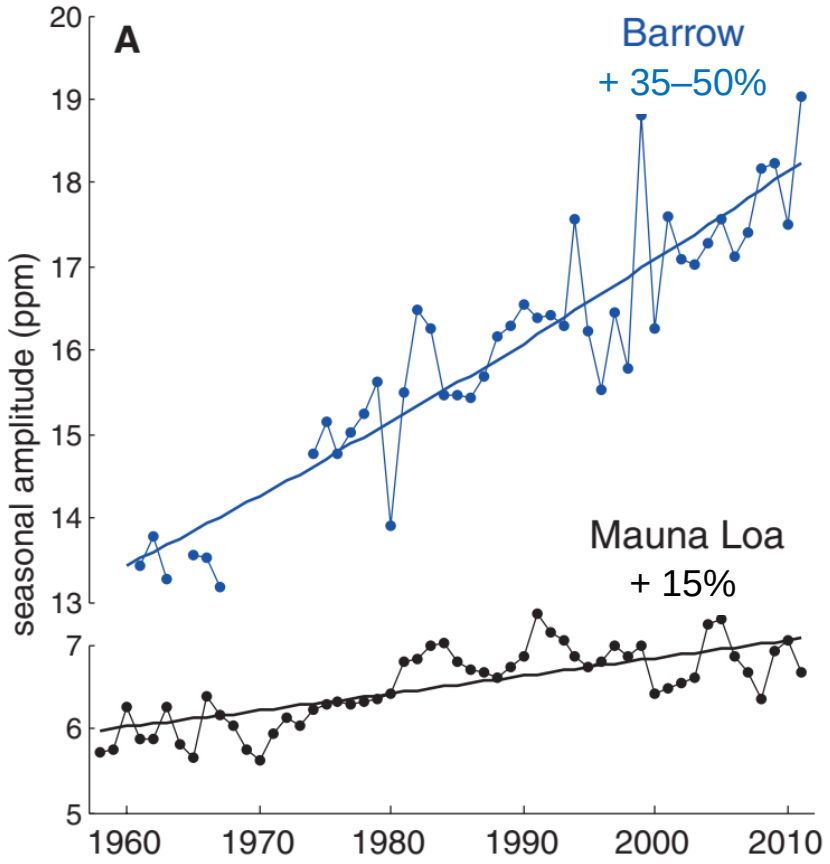




CO_2 seasonal cycle amplitude (SCA)

Amplification of CO_2 seasonal cycle in Northern Hemisphere over the past decades



(Graven et al. 2013 Science)

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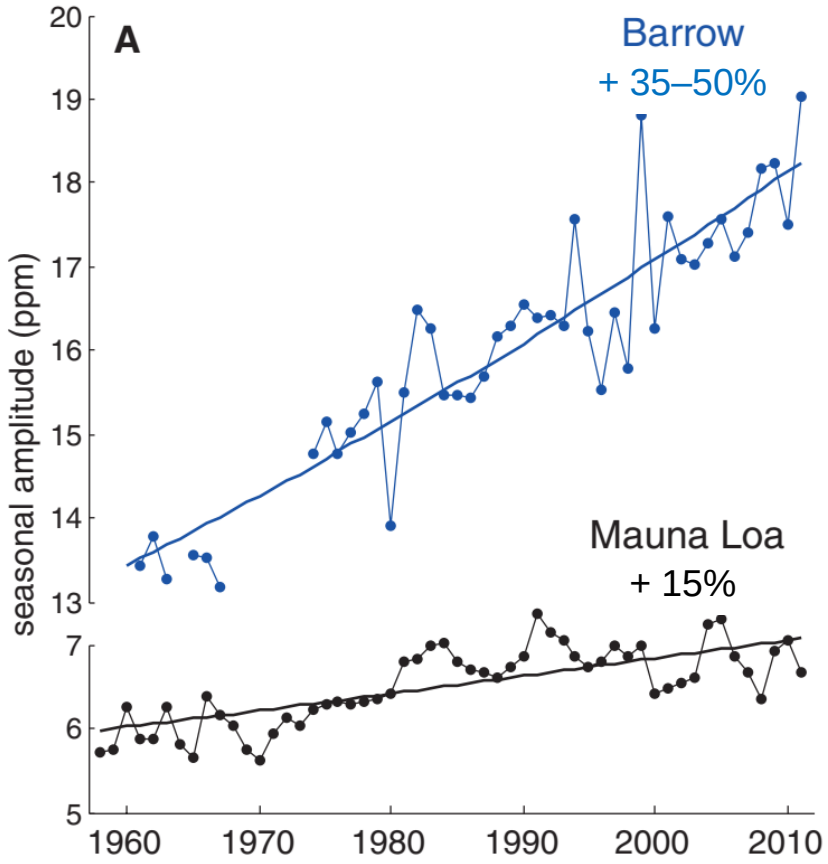

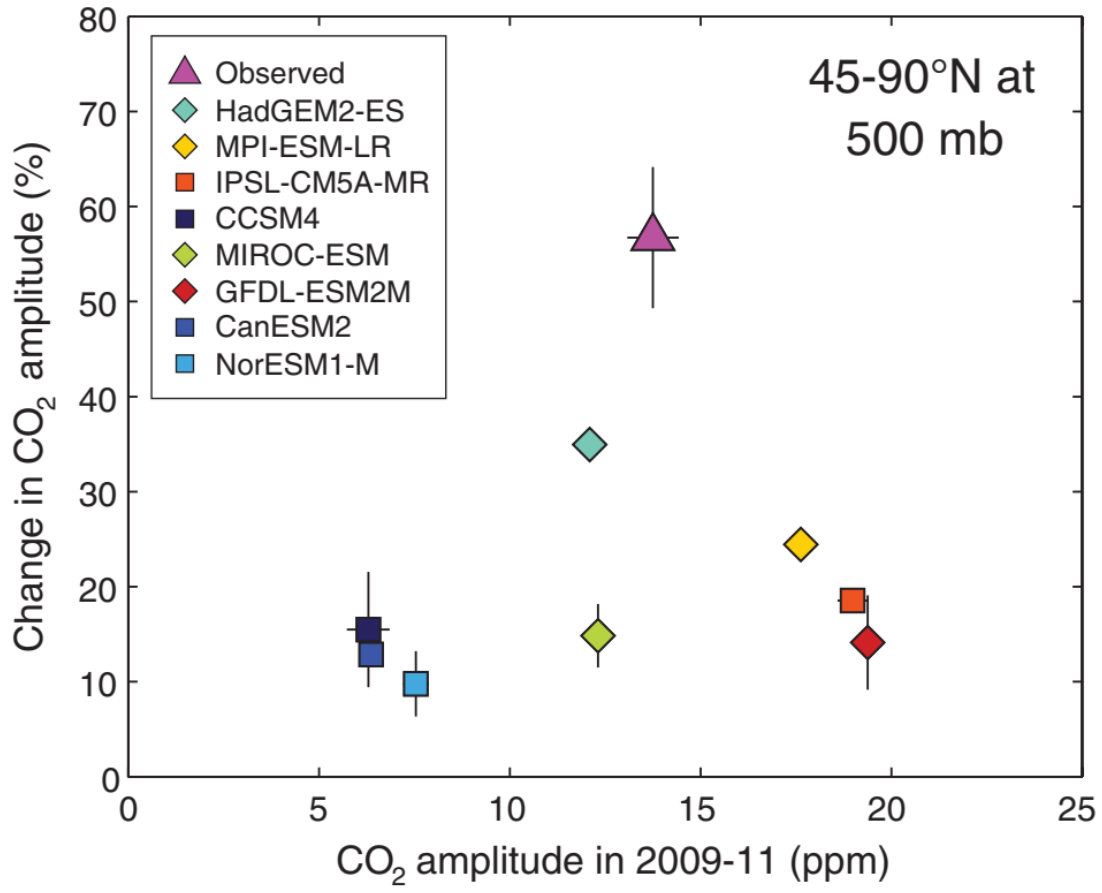

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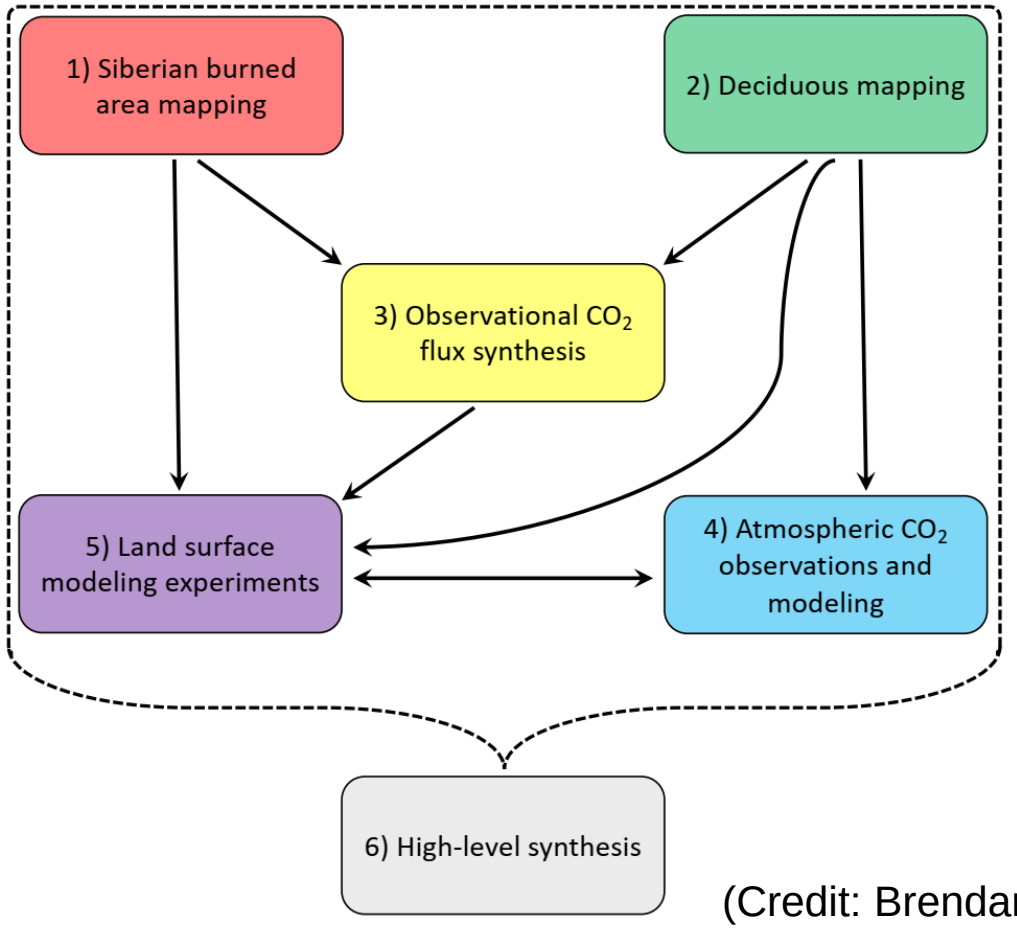
Understanding the Causes and Implications of Enhanced Seasonal CO_2 Exchange in Arctic and Boreal Ecosystems



(Credit: Brendan Rogers)

The Woods Hole Research Center

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Northern Arizona University

National Institute Of Aerospace

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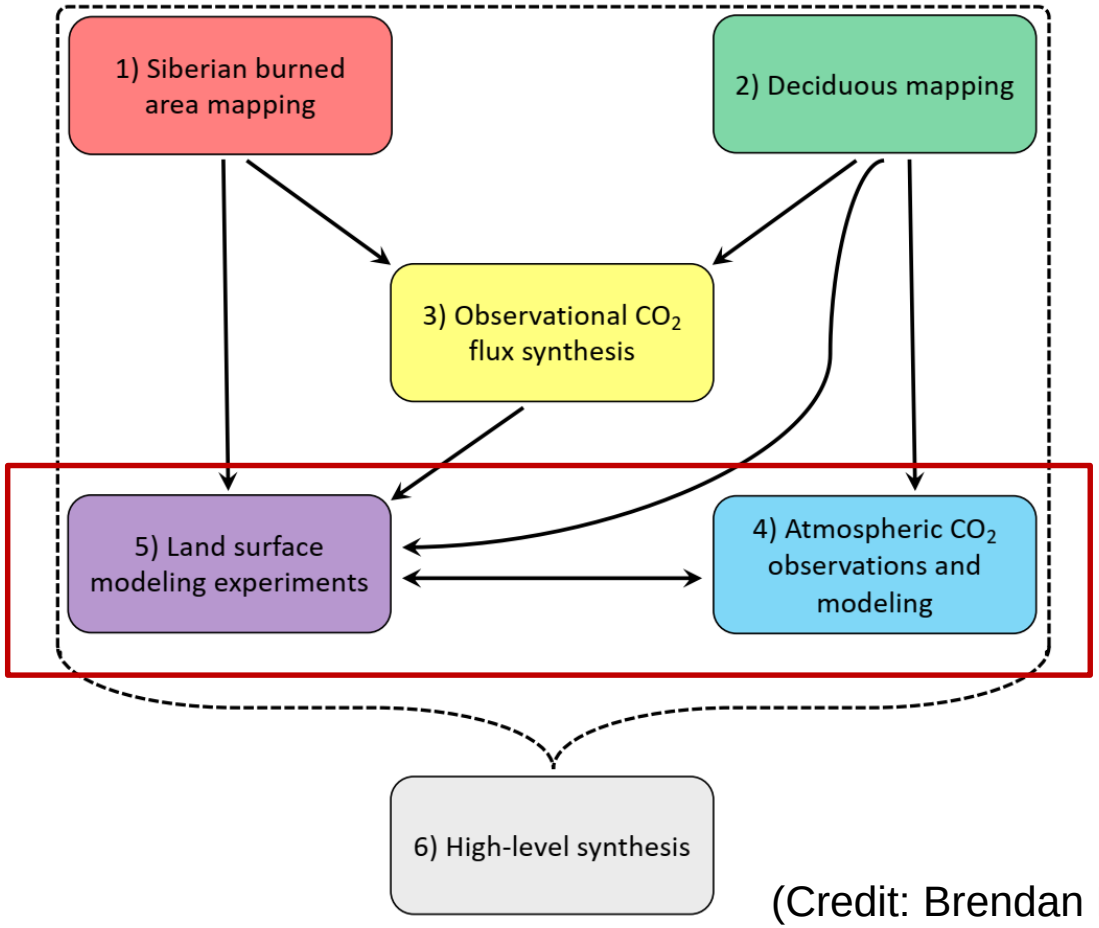

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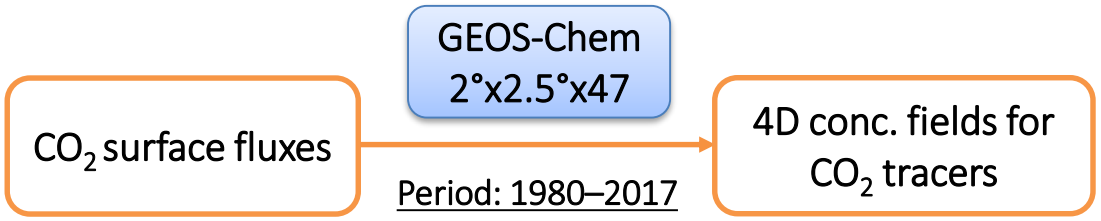
The tagged CO_2 transport model framework

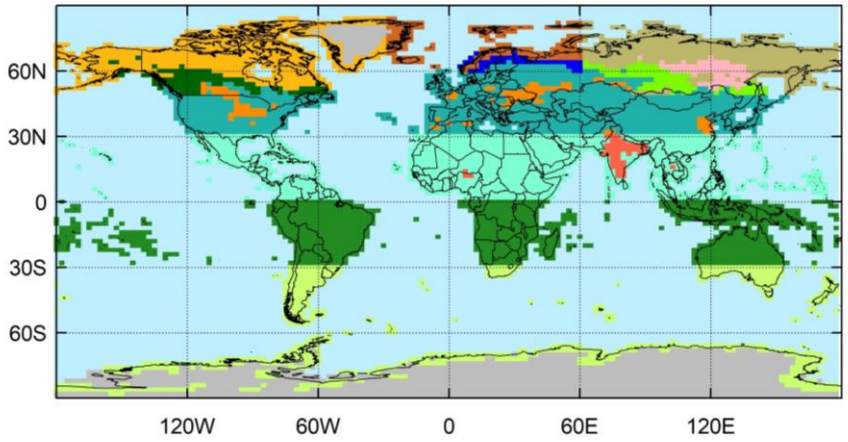


The tagged CO_2 transport model framework

CO_2 surface fluxes → GEOS-Chem 2°x2.5°x47 → 4D conc. fields for CO_2 tracers

Period: 1980–2017

	TRACER
Total vegetated area	CO2TR1
ArcNA	CO2TR2
ArcEU	CO2TR3
ArcSIB	CO2TR4
BorEnNA	CO2TR5
BorEnEU	CO2TR6
BorEnSIB	CO2TR7
BorDnSIB	CO2TR8
MidLatTemp	CO2TR9
NatPFTs_0_30N	CO2TR10
PFTs_0_30S	CO2TR11
PFTs_30_90S	CO2TR12
CROP_0_30N	CO2TR13
CROP_30_60N	CO2TR14
Non-vegetated	
Ocean	



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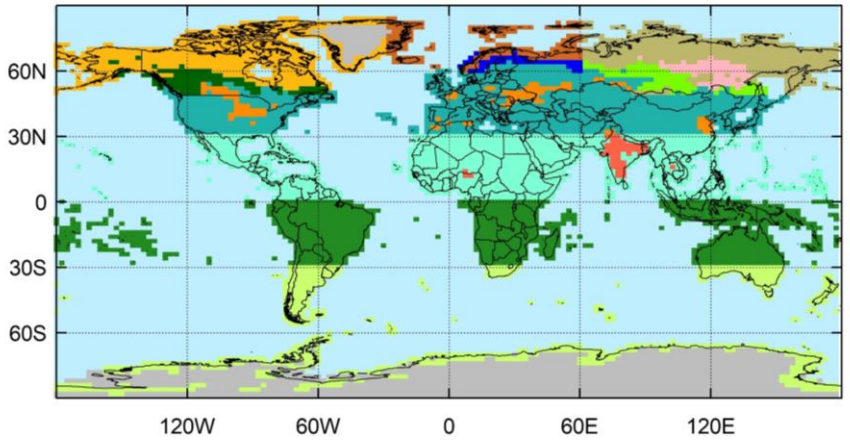
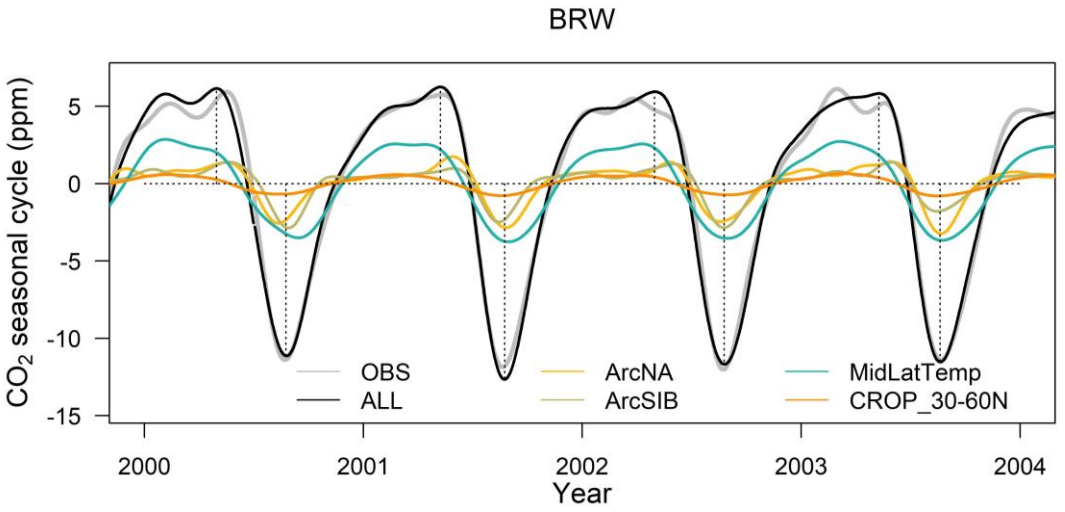




The tagged CO_2 transport model framework

CO_2 surface fluxes

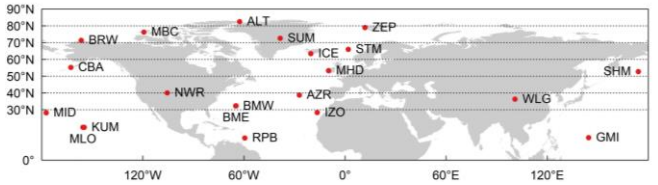
GEOS-Chem 2°x2.5°x47

Period: 1980–2017

4D conc. fields for CO_2 tracers

Sampled at observation location

Simulated CO_2 tracers



Seasonal cycle extraction

- Evaluation against obs.
- Contribution to SCA
- Contribution to SCA trend

	TRACER
Total vegetated area	CO2TR1
ArcNA	CO2TR2
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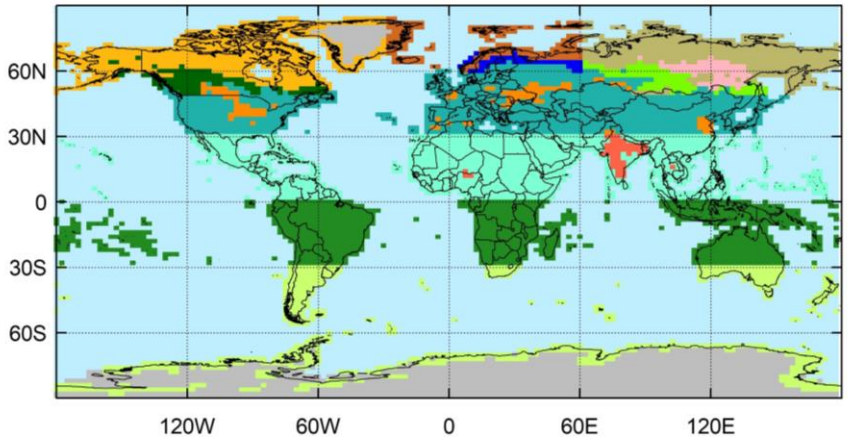
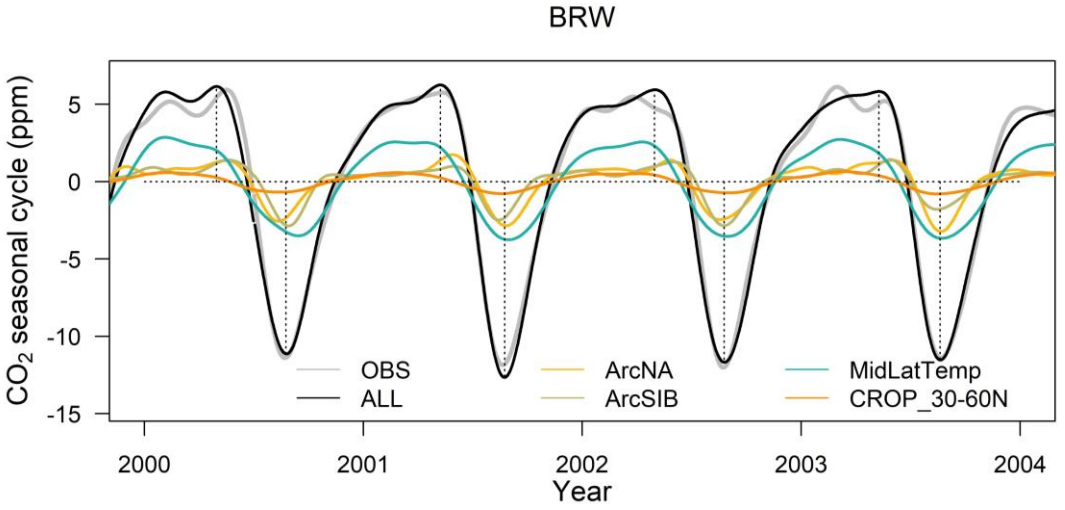
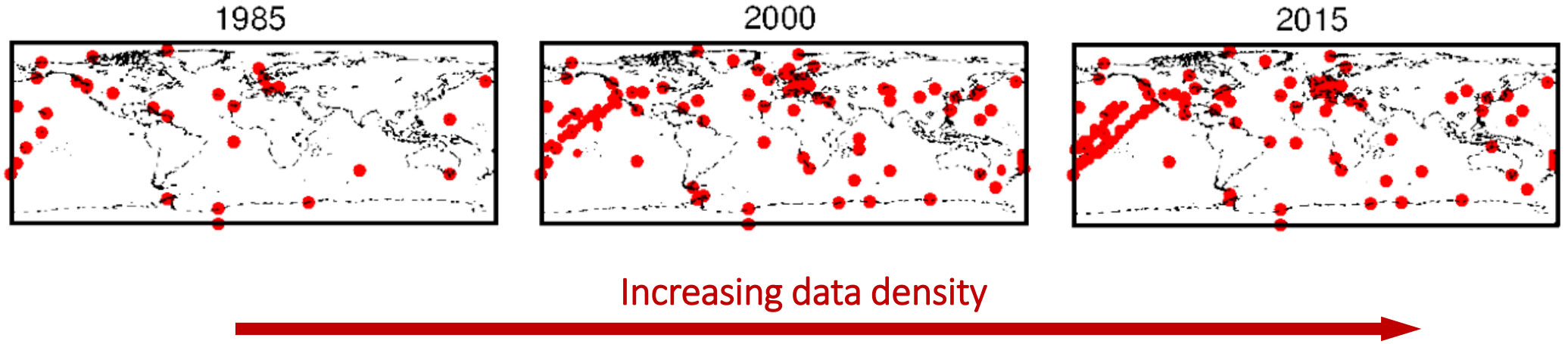




The inverted CO_2 surface fluxes used to drive the transport model

- Monthly NEE from CAMS (Copernicus Atmosphere Monitoring Service) CO_2 inversion v17r1 (2018)
- Flux uncertainty associated to transport errors and data density

Location of the assimilated observations over the globe



(Adapted from Chevallier et al. 2018)

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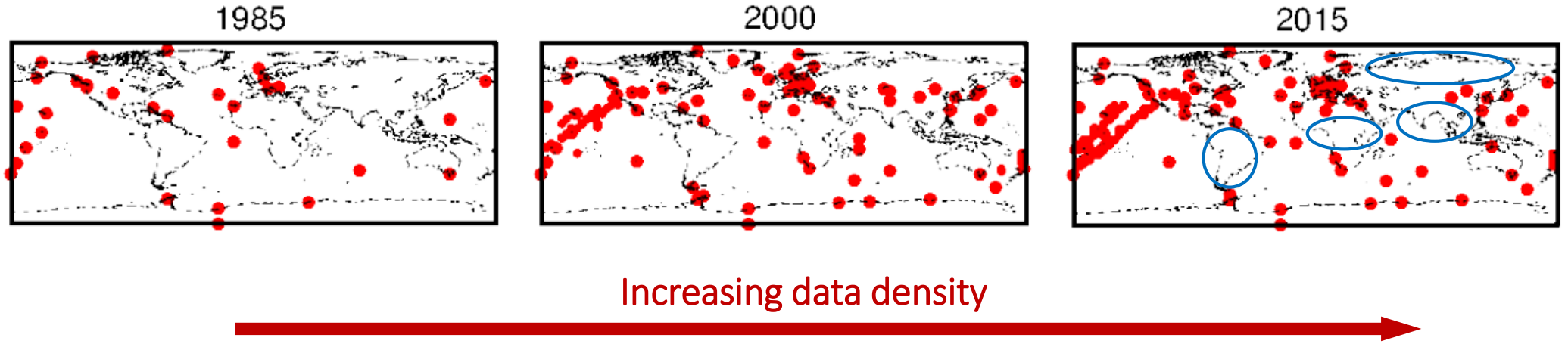

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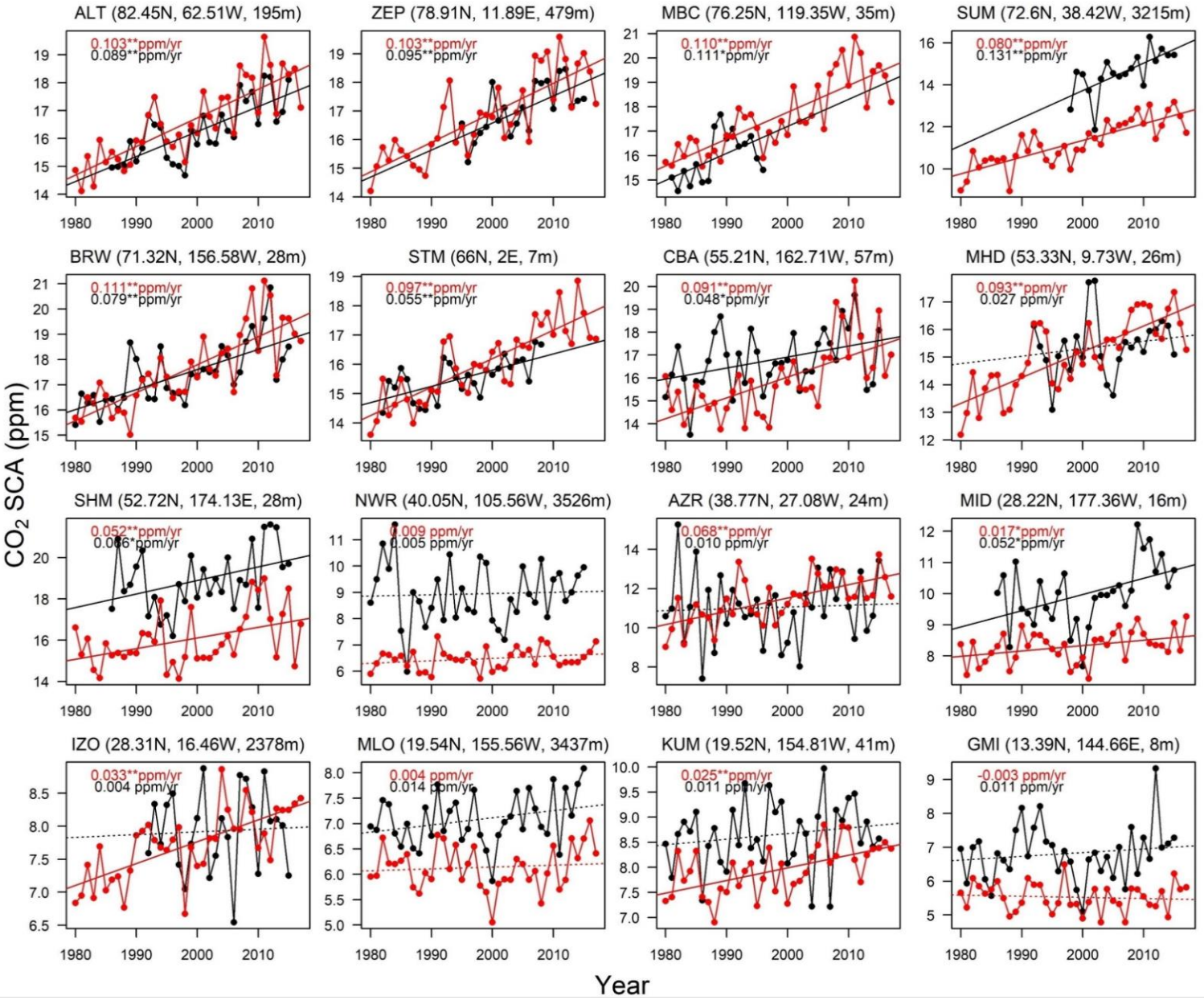
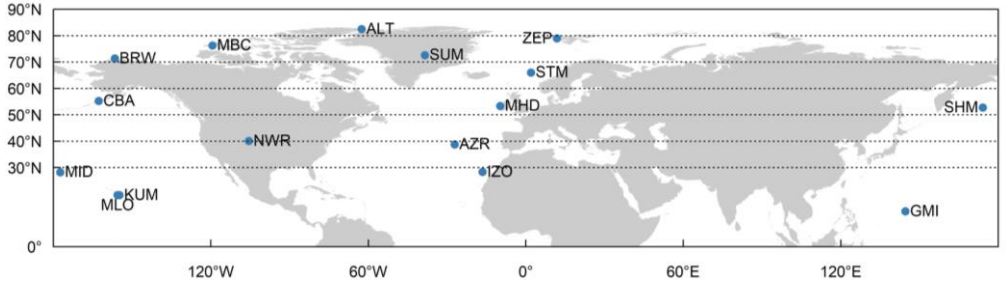
Modelled vs. Observed CO_2 seasonal cycle amplitude – NOAA stations





MOD

OBS

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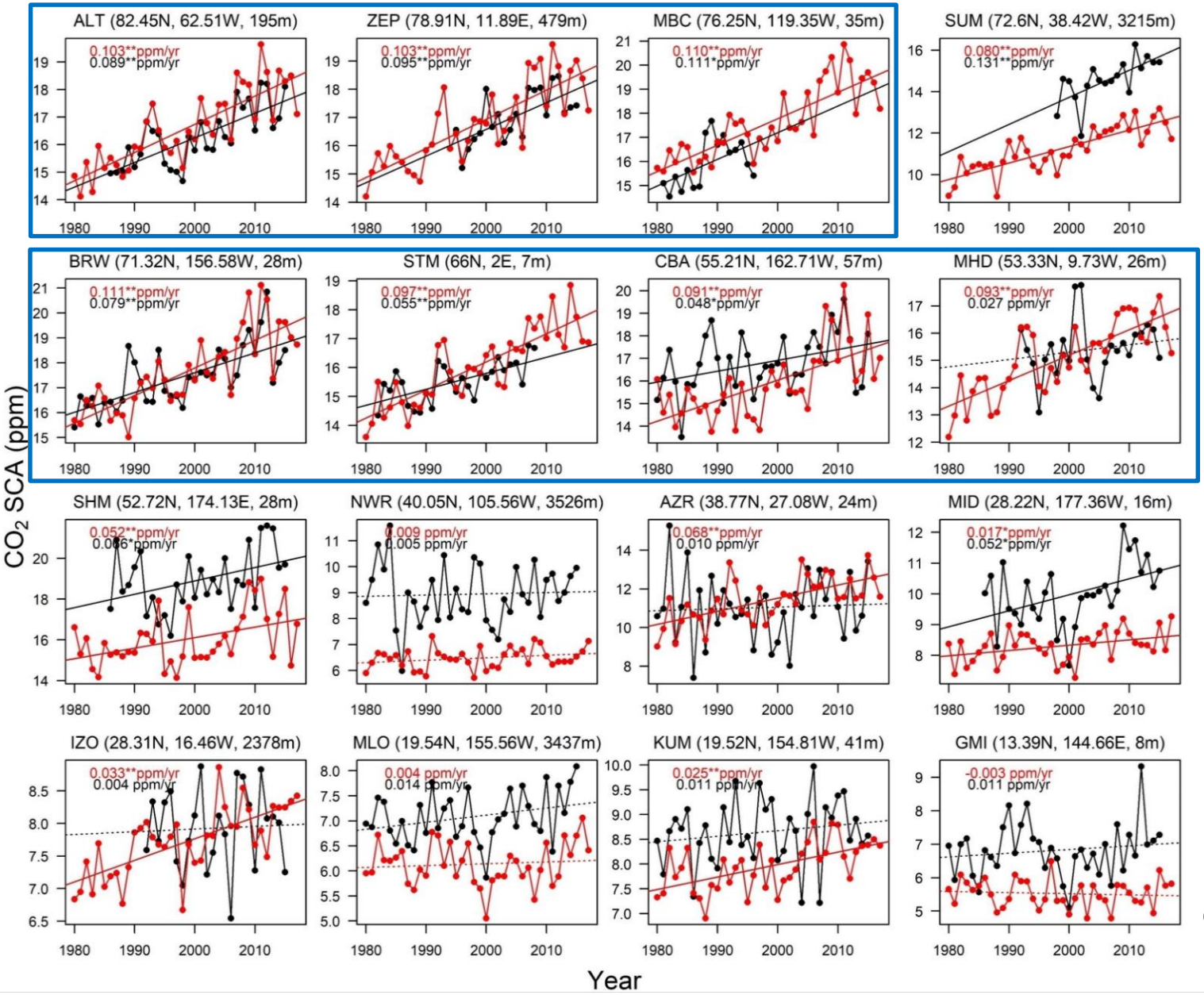

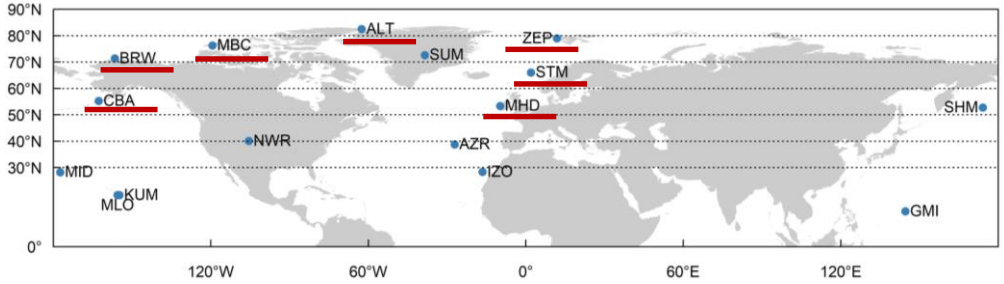

- Good at most northern high latitude stations

MOD
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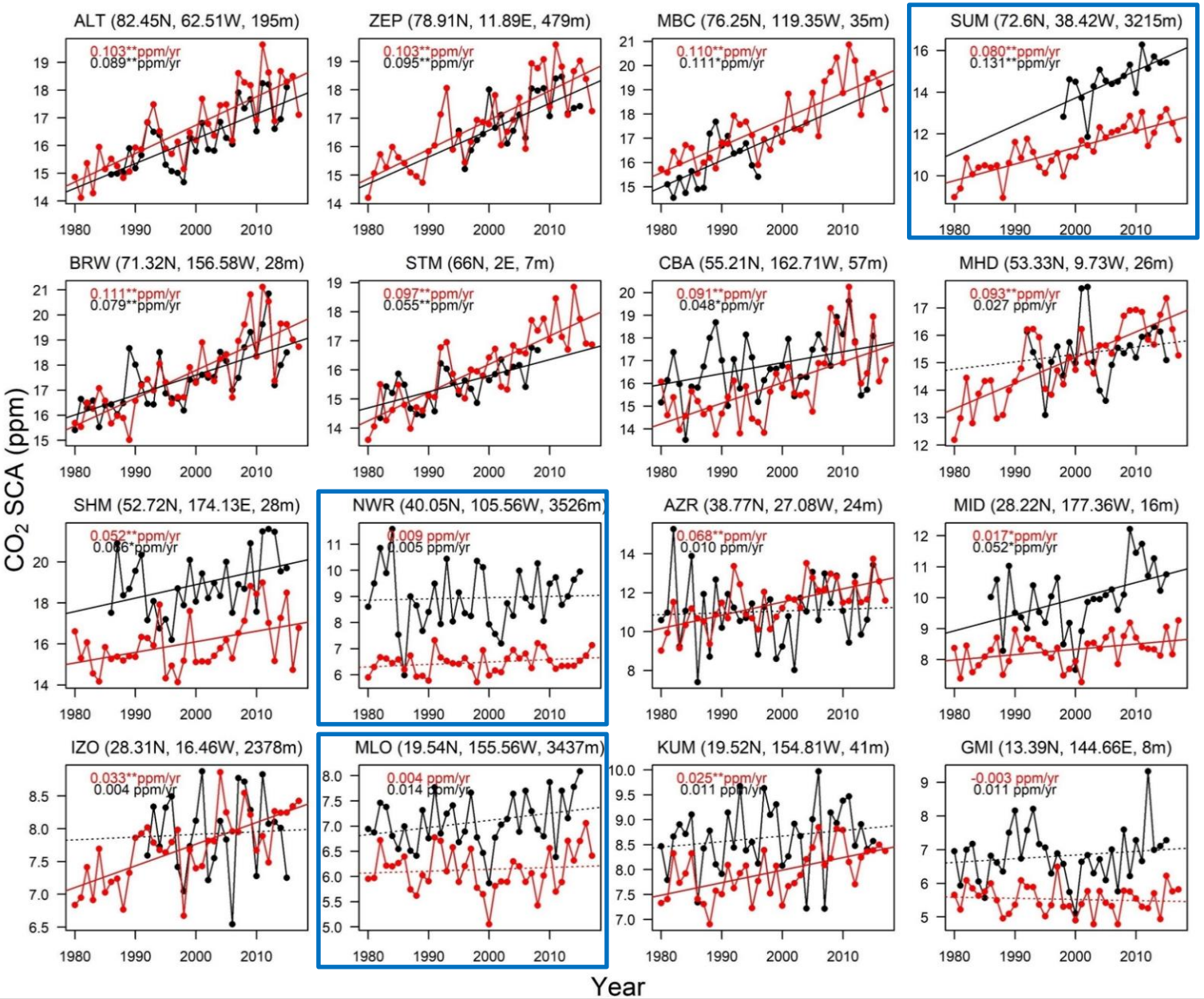

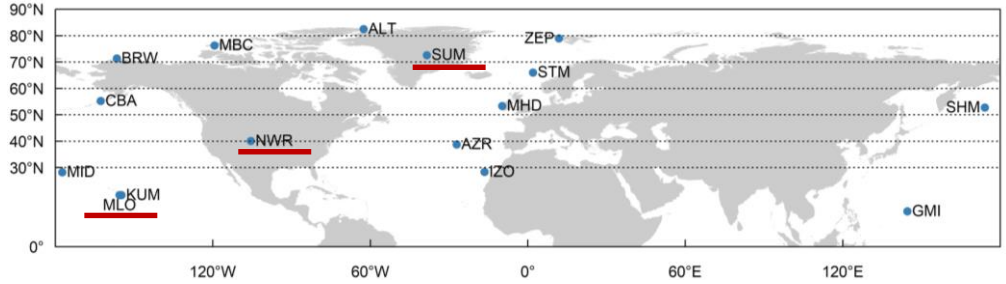

- Good at most northern high latitude stations
- Underestimation of SCA at mountain stations (SUM, NWR, MLO)

MOD
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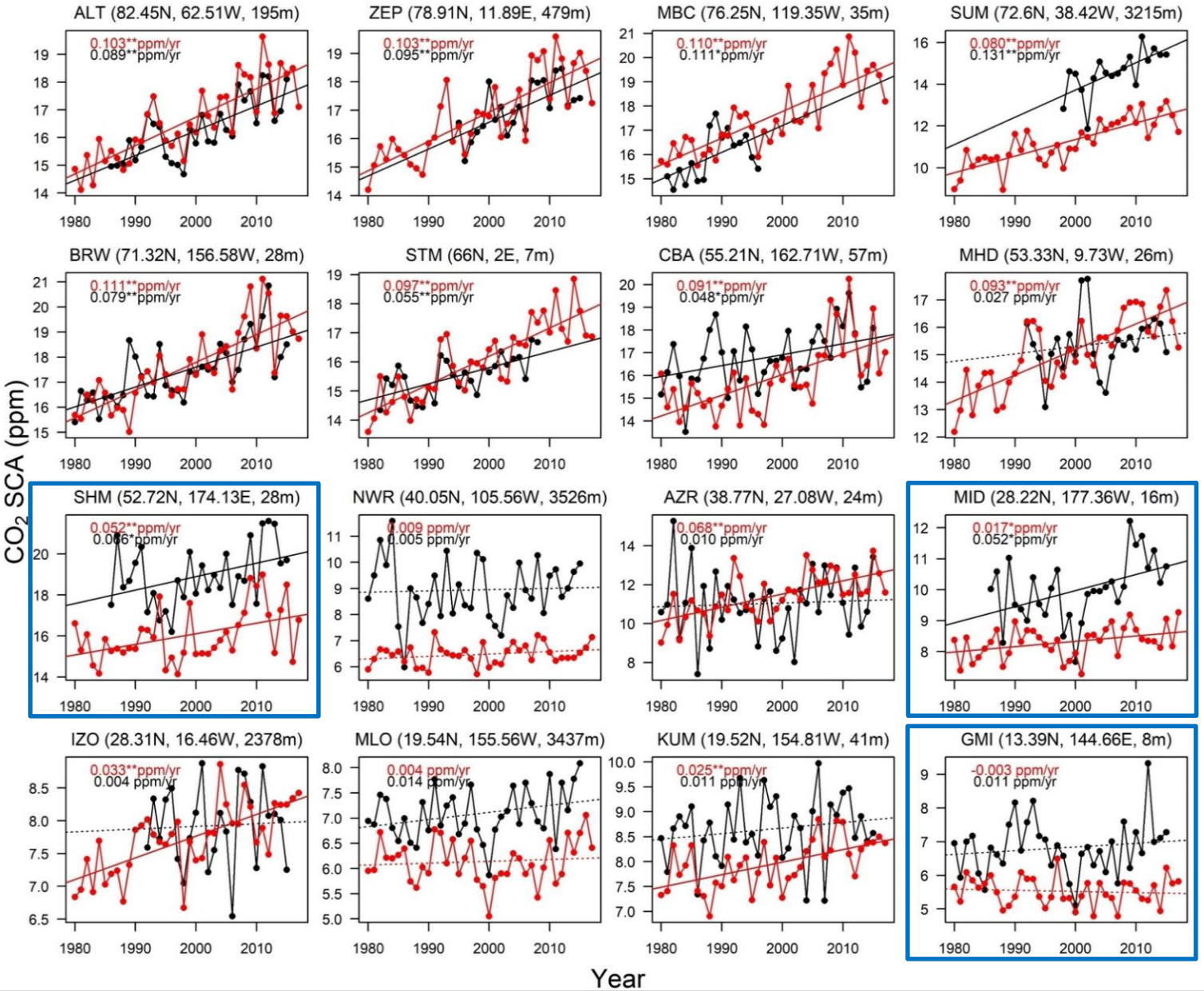
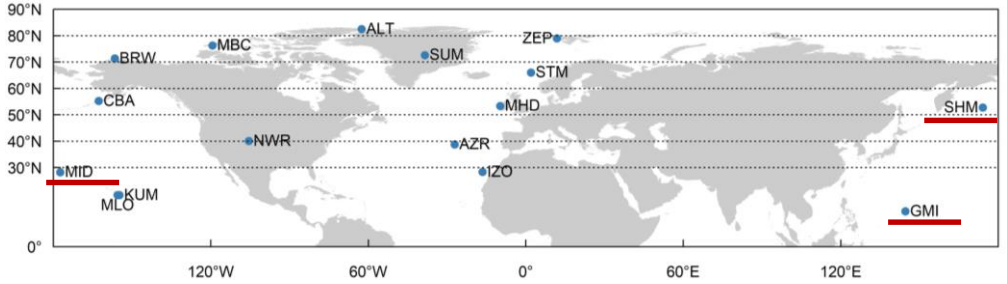
Modelled vs. Observed CO_2 seasonal cycle amplitude – NOAA stations

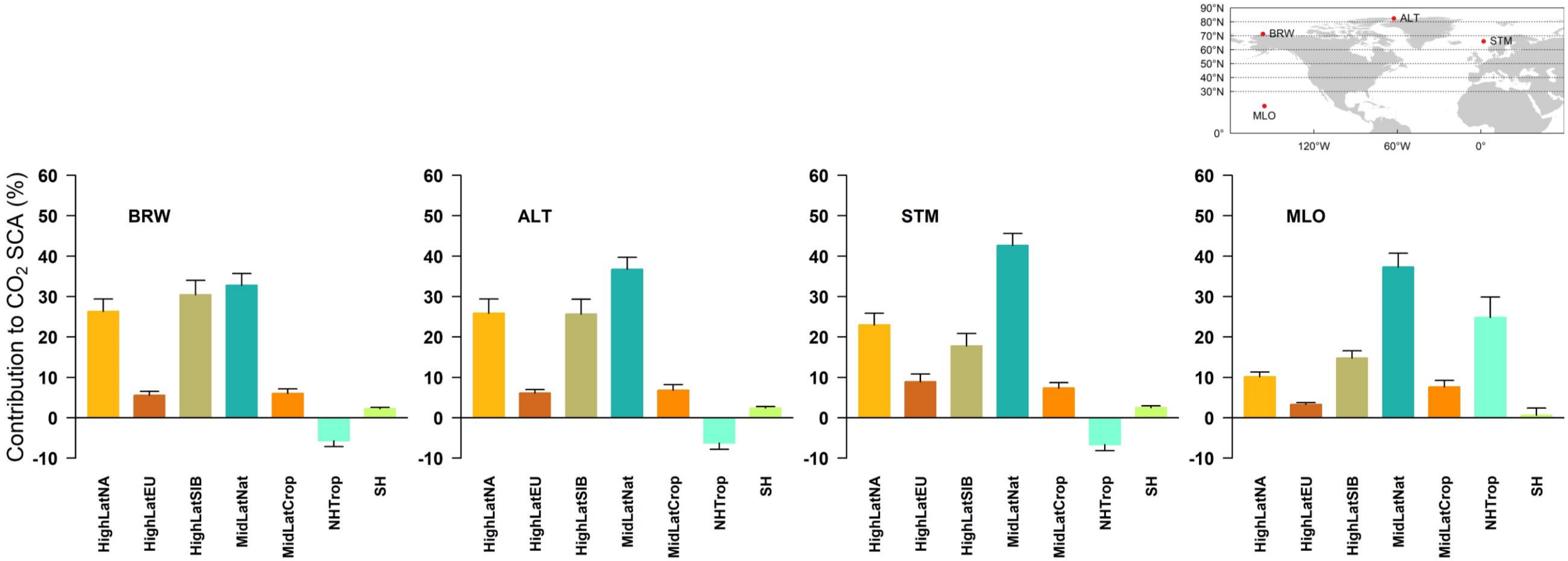




- Good at most northern high latitude stations
- Underestimation of SCA at mountain stations (SUM, NWR, MLO)
- Underestimation of SCA at Pacific stations (SHM, MID, GMI)

MOD
OBS

Contribution to SCA from different regions



	HighLatNA	HighLatSIB	MidLatNat	MidLatCrop
Northern high stations	~20–30%	~20–30%	~30–40%	<10%

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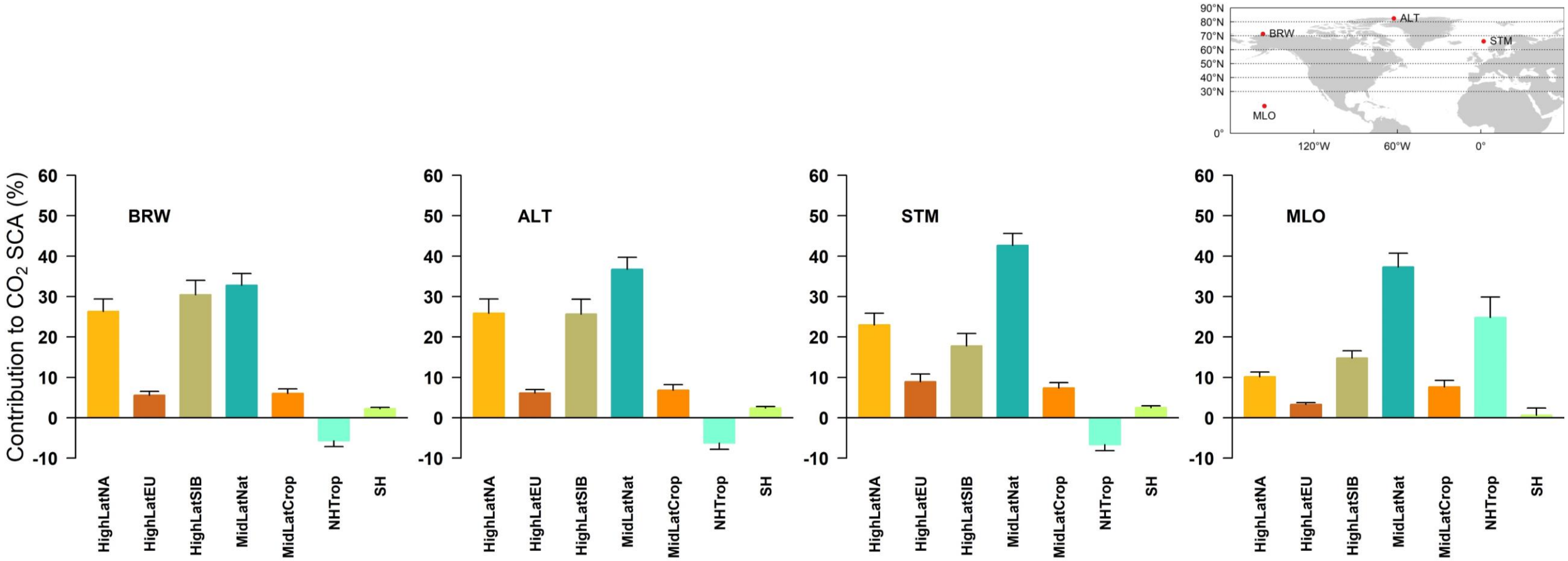
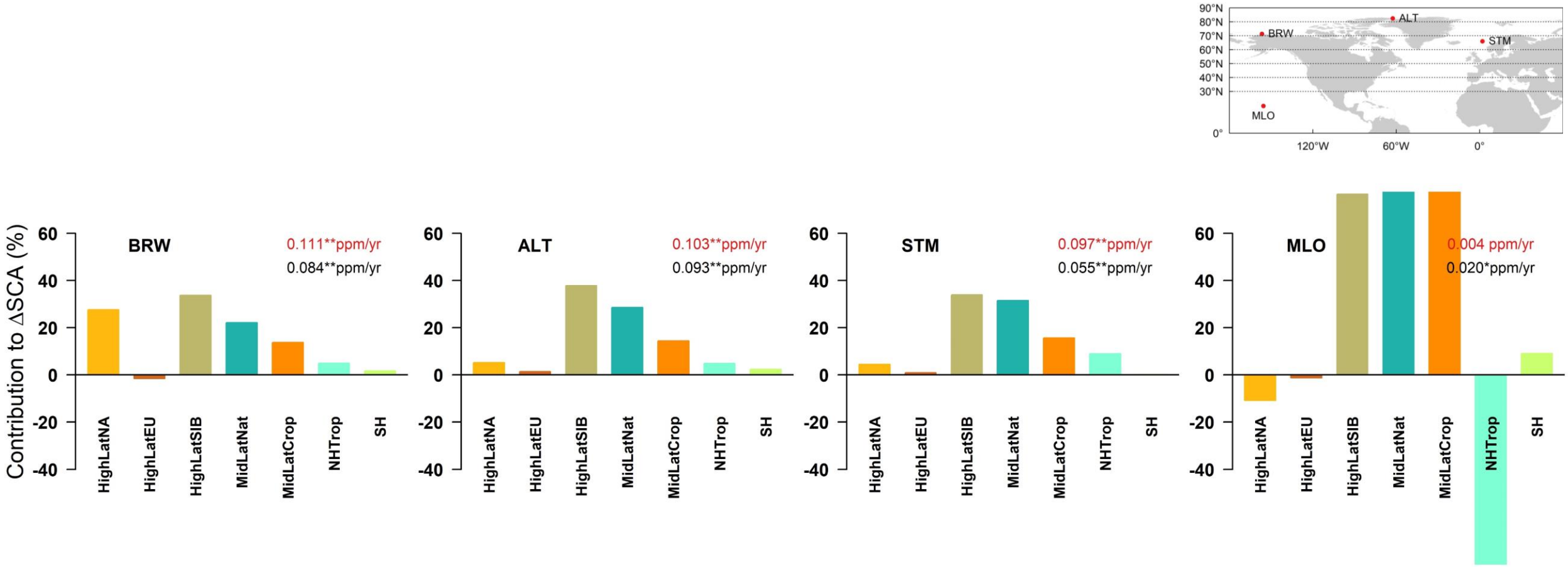


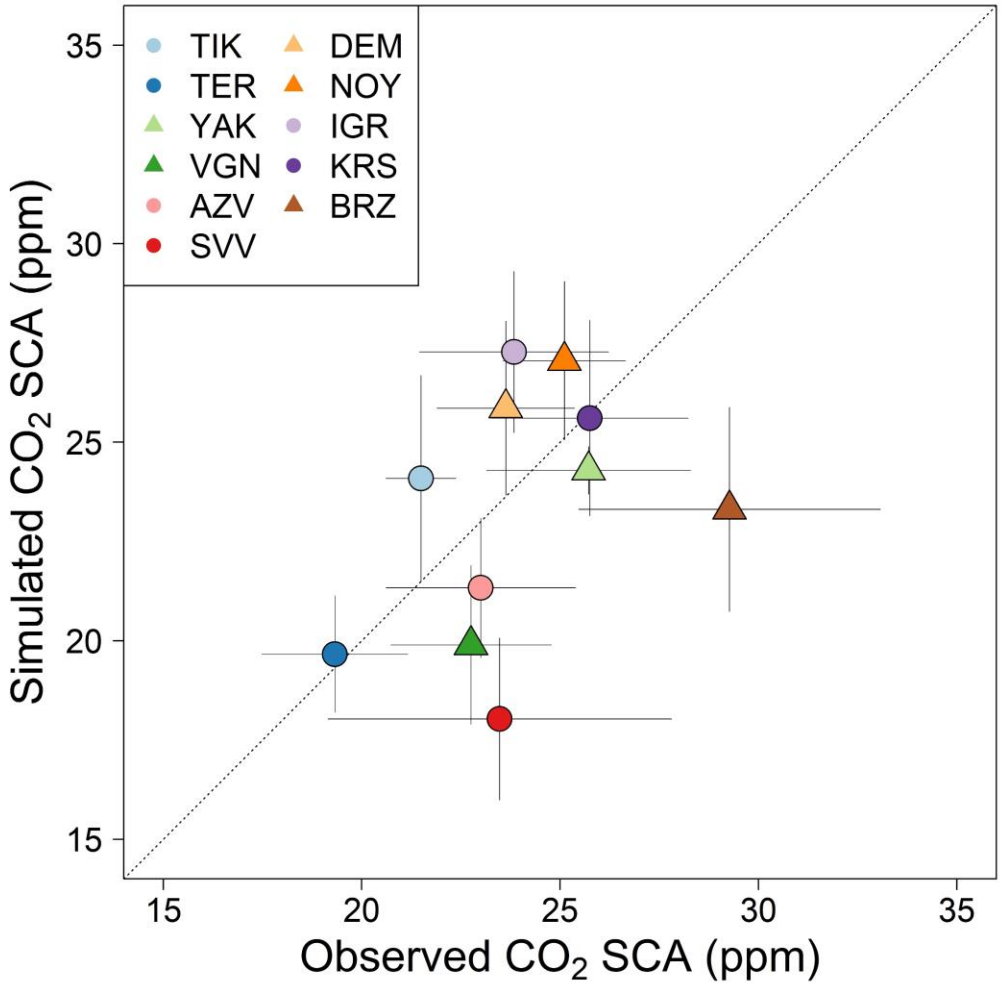
	HighLatNA	HighLatSIB	MidLatNat	MidLatCrop
Northern high stations	~20–30%	~20–30%	~30–40%	<10%
MLO	10%	15%	37%	<10%

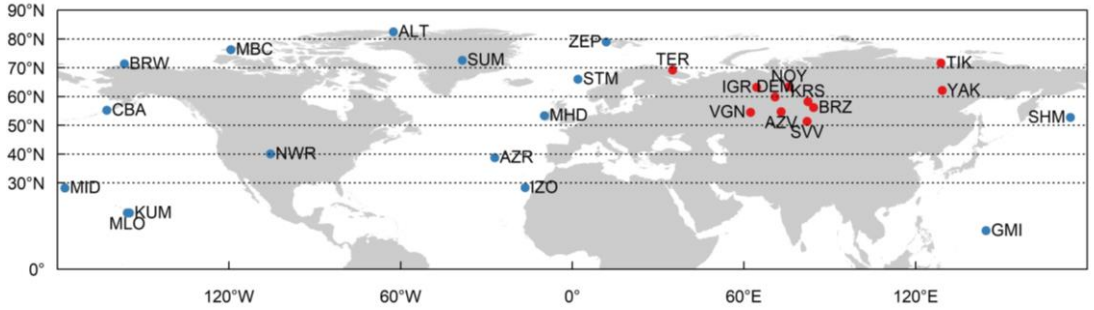
Contribution to SCA changes in Northern high latitudes from different regions



	HighLatNA	HighLatSIB	MidLatNat	MidLatCrop
Northern high stations	28% for BRW	~30–40%	~20–30%	~10%

Modelled vs. Observed CO_2 seasonal cycle amplitude – Siberia stations





- Model results are reasonable at Siberia stations even though they are not assimilated in the CO_2 inversion

Summary and perspective

1 Dominant regional contributor to CO_2 SCA and changes in Northern high latitude:

	HighLatNA	HighLatSIB	MidLatNat
Contrib. to CO_2 SCA	~20–30%	~20–30%	~30–40%
Contrib. to SCA change	depends	~30–40%	~20–30%

Summary and perspective

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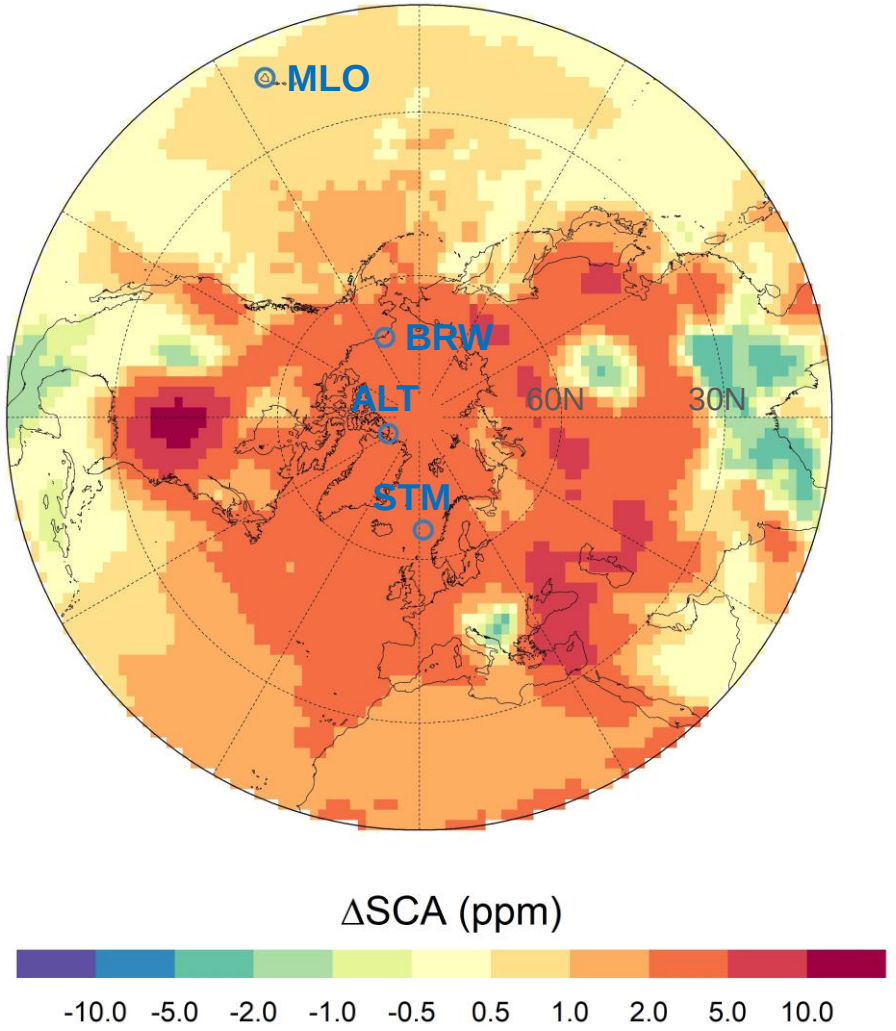
2. An “extrapolation” of site-based analyses to pixel-based analyses



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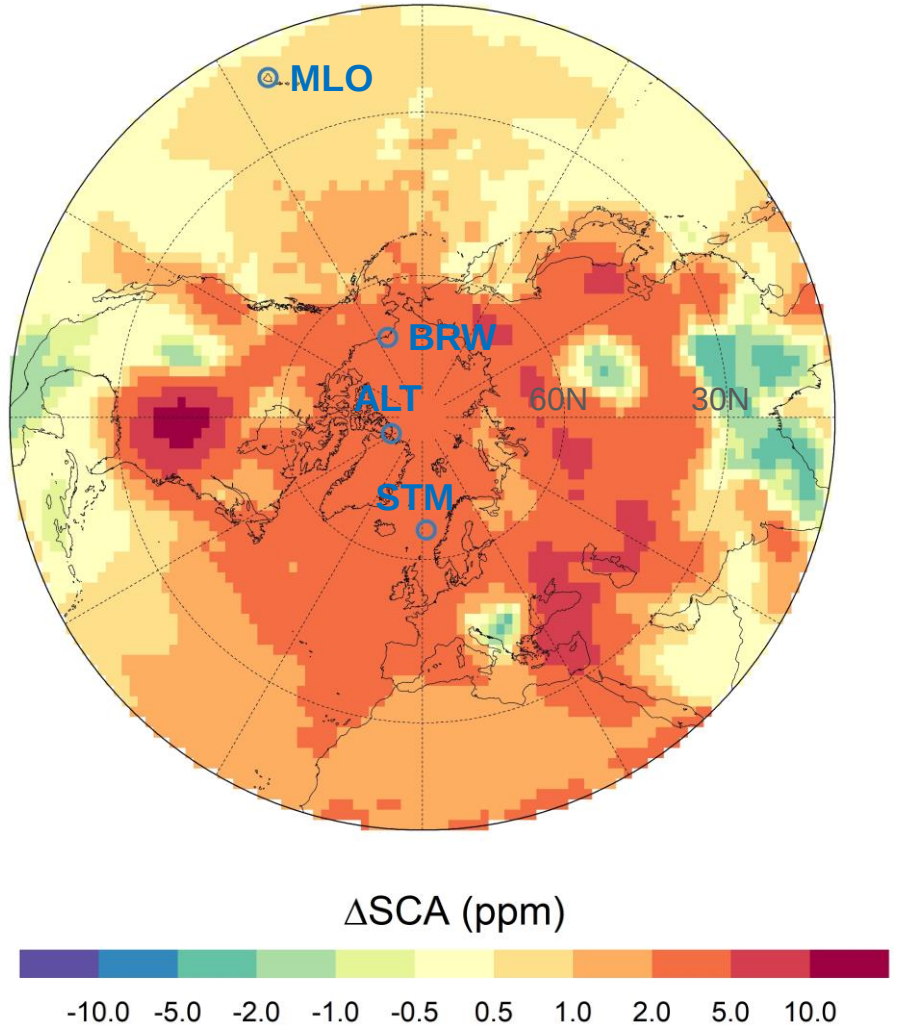
2. An “extrapolation” of site-based analyses to pixel-based analyses

3. Application of this tag model framework to land surface model for more hypothesis-driven studies on CO_2 seasonal amplification.



Acknowledgement

- Collaborators

  Brendan Rogers (WHRC)

  Leah Birch (WHRC)

- Funding resource

  NASA Grant NNX17AE13G

- NOAA ESRL for CO_2 flask measurements
- NIES and MGO for CO_2 measurements in Russia
- GEOS-Chem model development group
- CAMS CO_2 inversion group

Thanks!

Contact: xinlinn@umich.edu