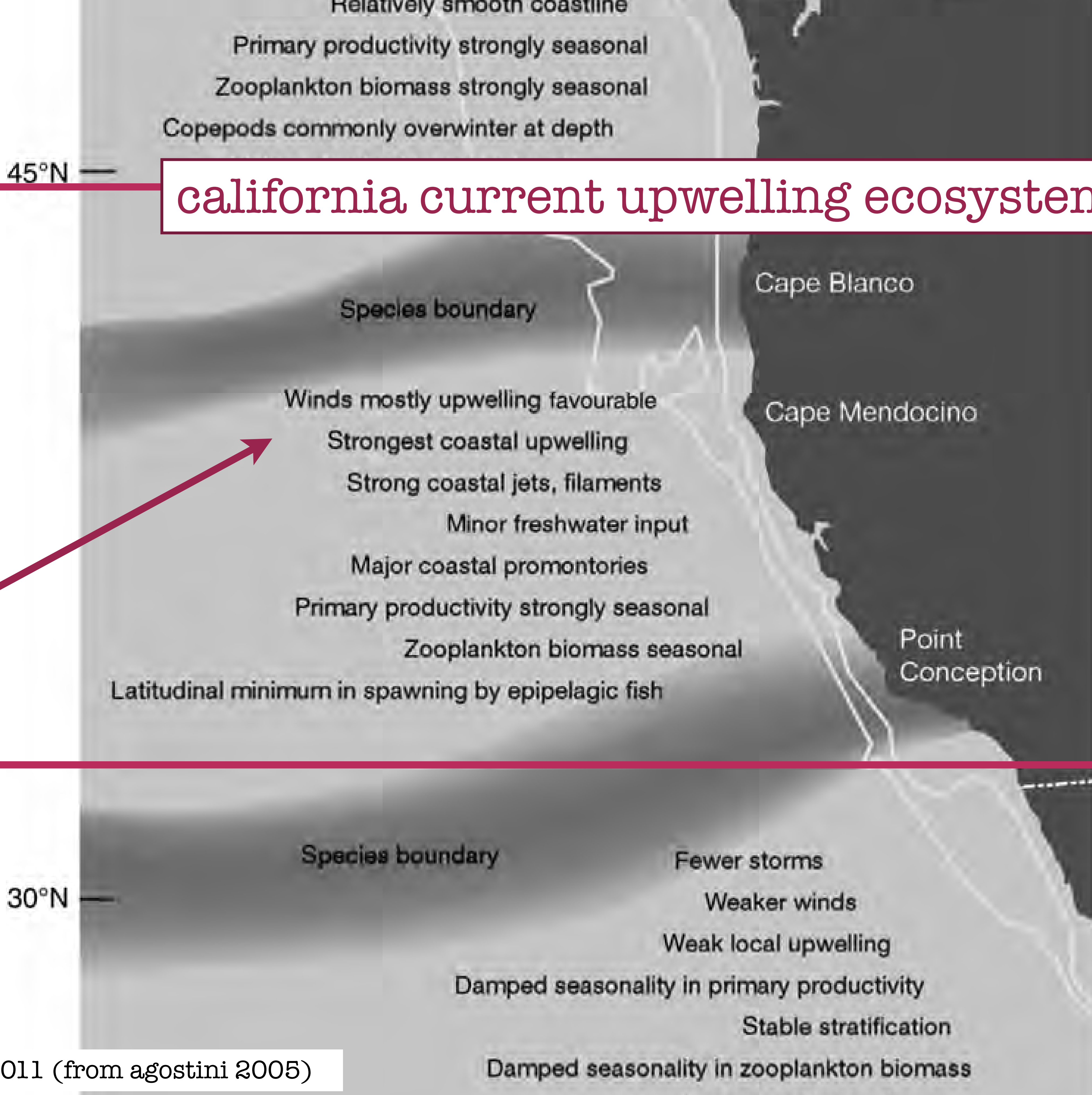
what do **global climate models** say about **increasing variance** in the california current **upwelling ecosystem**

marisol **garcía-reyes**

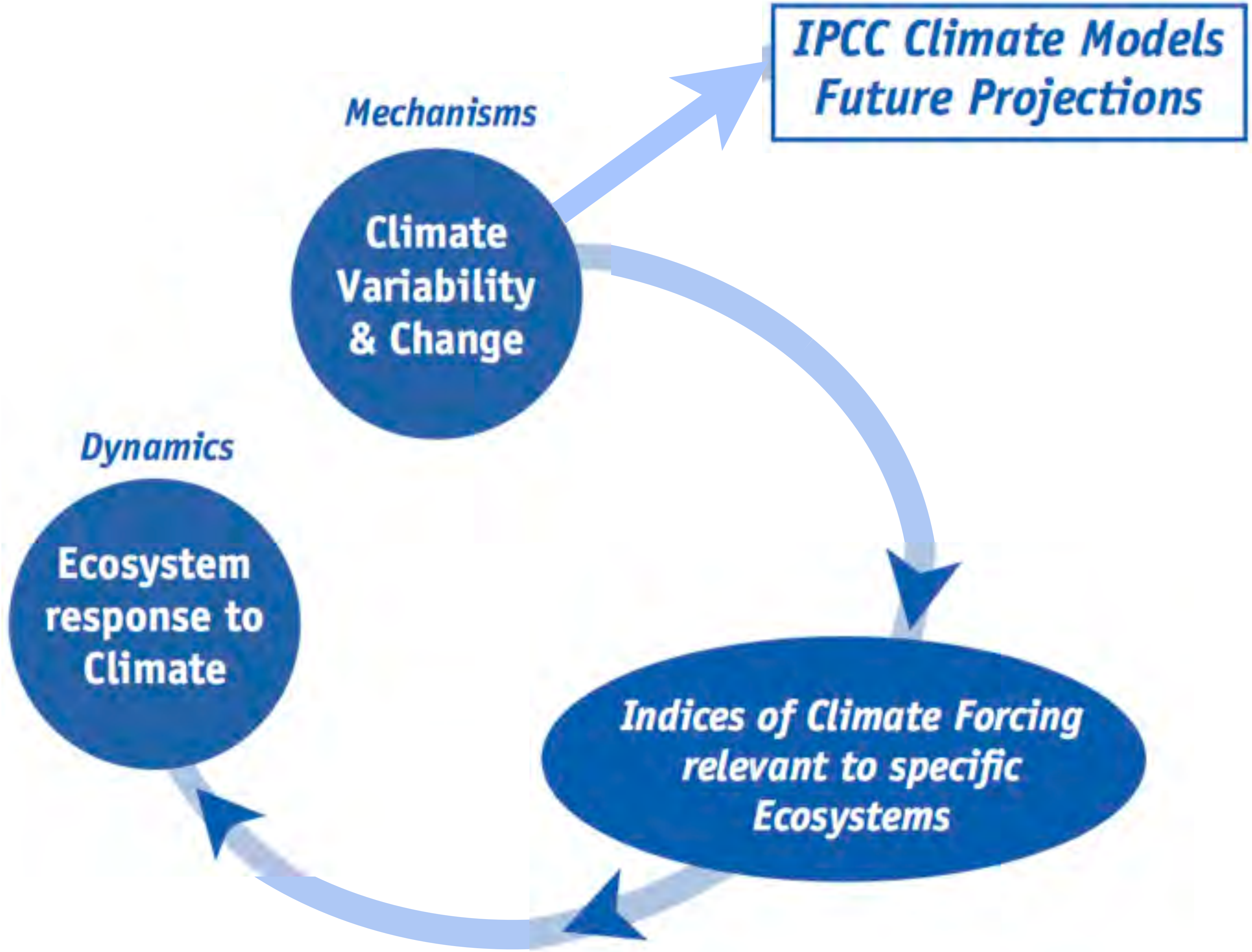
farallon institute for advanced ecosystem research

william **sydeman**, ryan **rykaczewski**, allison **wiener**, isaac **schroeder** & steven **bograd**

california current upwelling ecosystem



king et al. 2011 (from agostini 2005)

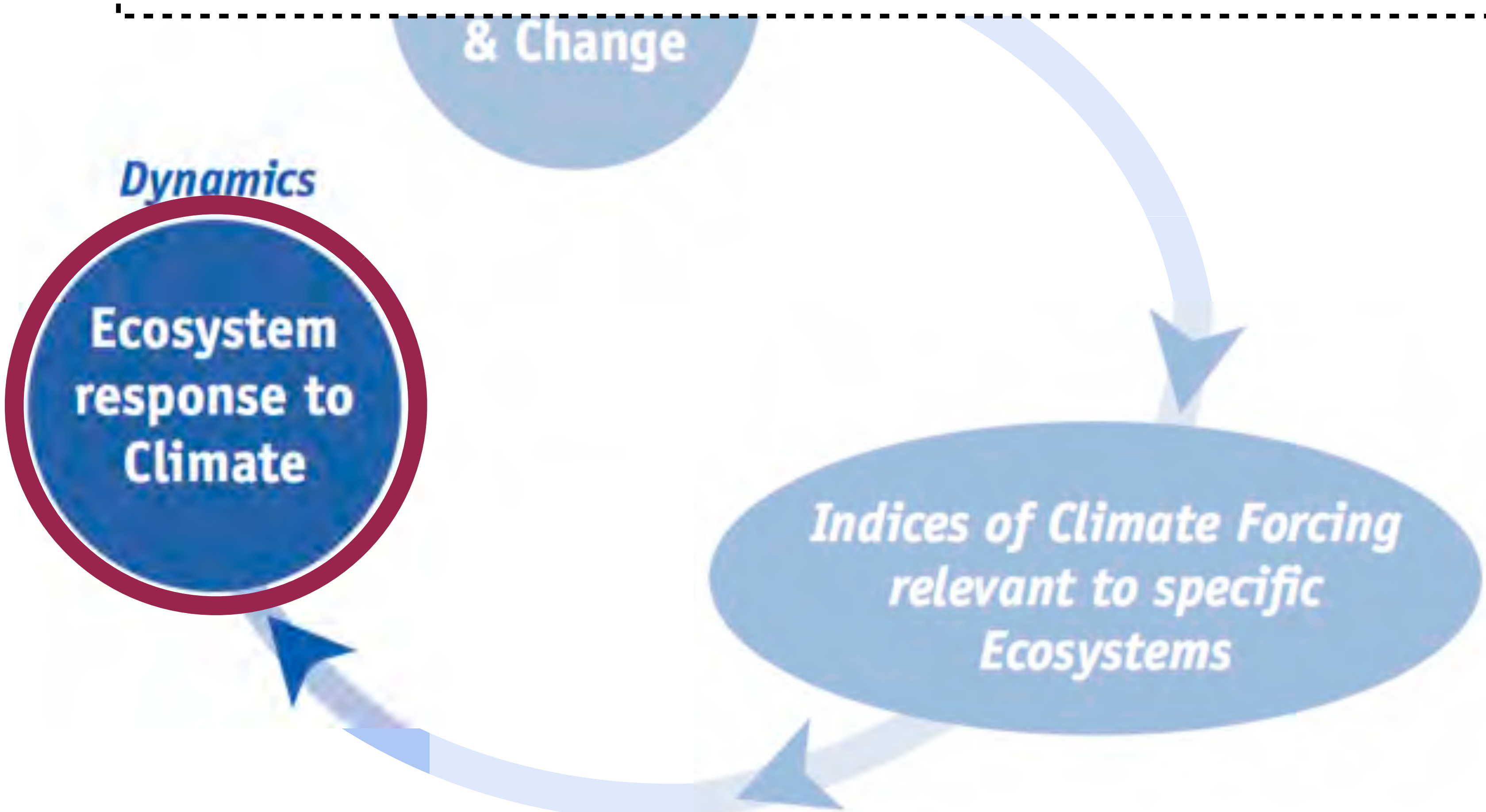

IPCC Climate Models
Future Projections
Mechanisms
Climate Variability & Change
Dynamics
Ecosystem response to Climate
Indices of Climate Forcing relevant to specific Ecosystems

Global Change Biology

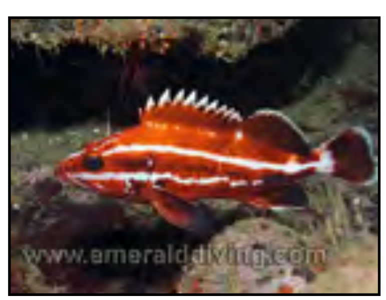
Global Change Biology (2013) **19**, 1662–1675, doi: 10.1111/gcb.12165

Increasing variance in North Pacific climate relates to unprecedented ecosystem variability off California

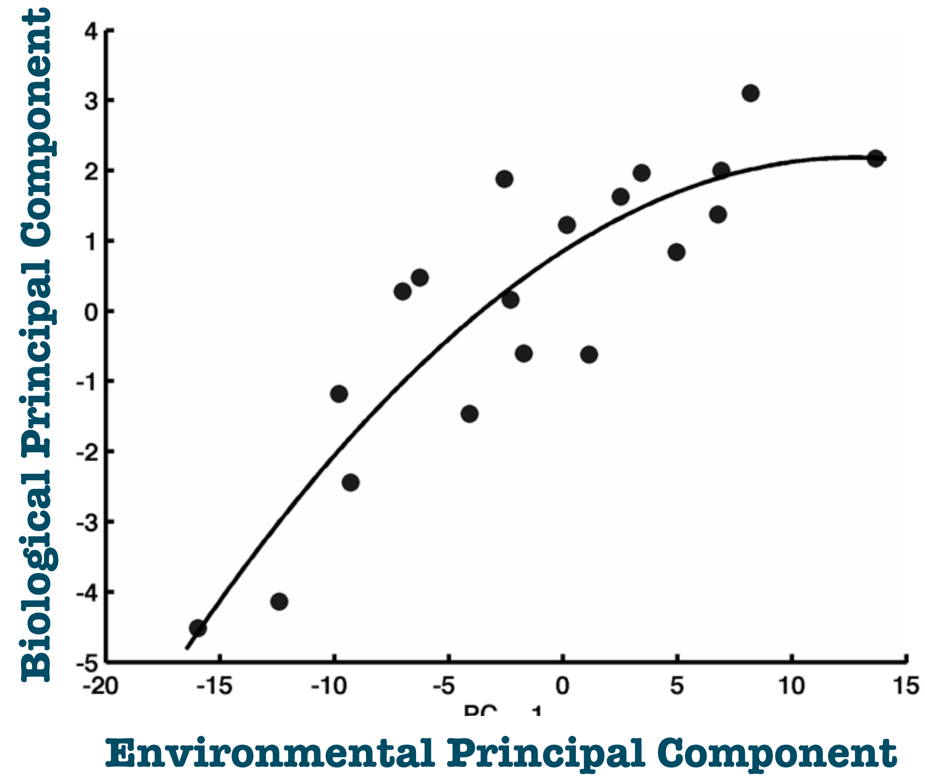
WILLIAM J. SYDEMAN*, JARROD A. SANTORA*, SARAH ANN THOMPSON*, BALDO MARINOVIC† and EMANUELE DI LORENZO‡



ecosystem sensitivity to winter upwelling variability



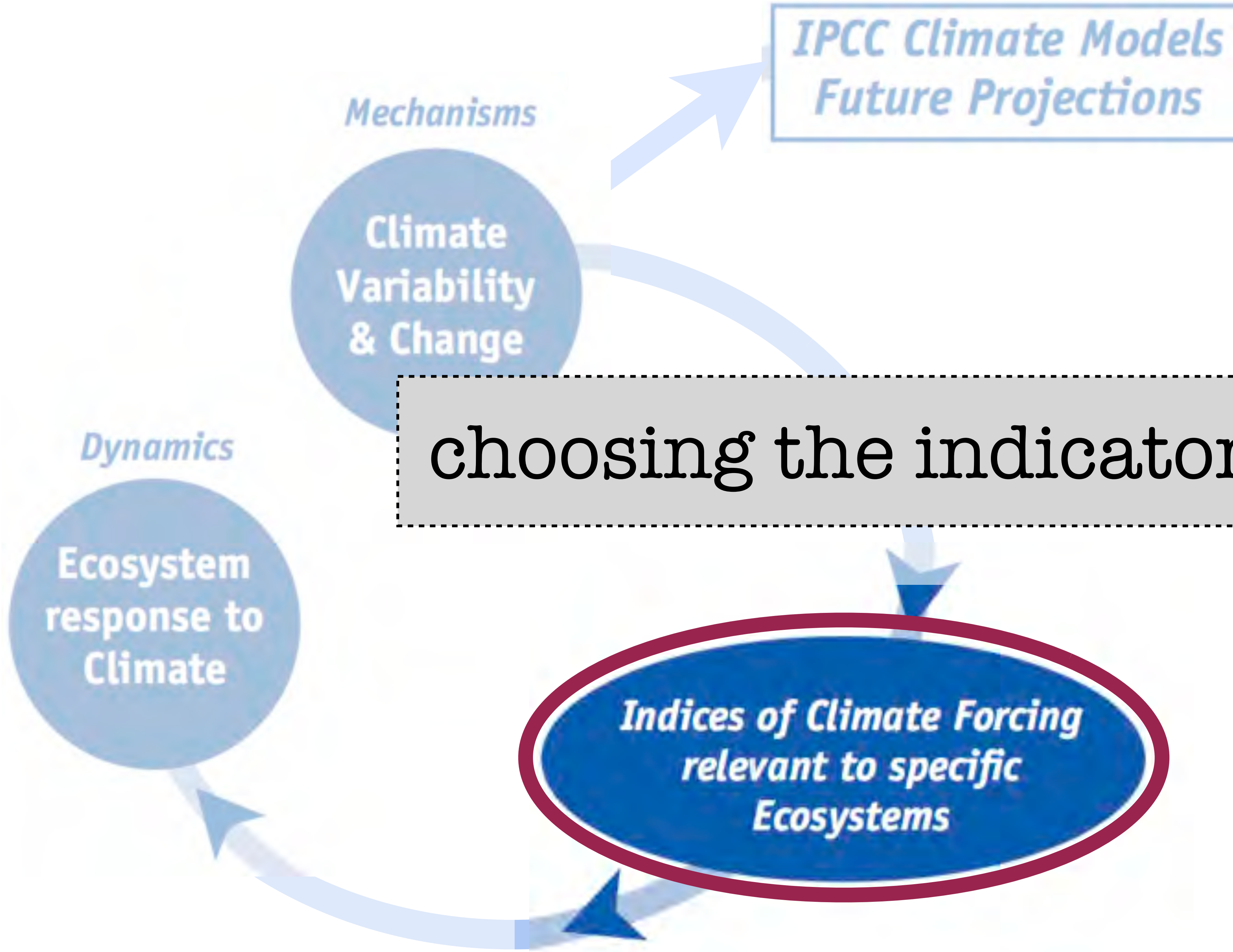
egg lay-date, reproductive success, growth



sst & winds

cordell bank website

garcía-reyes et al., 2013



choosing the indicators

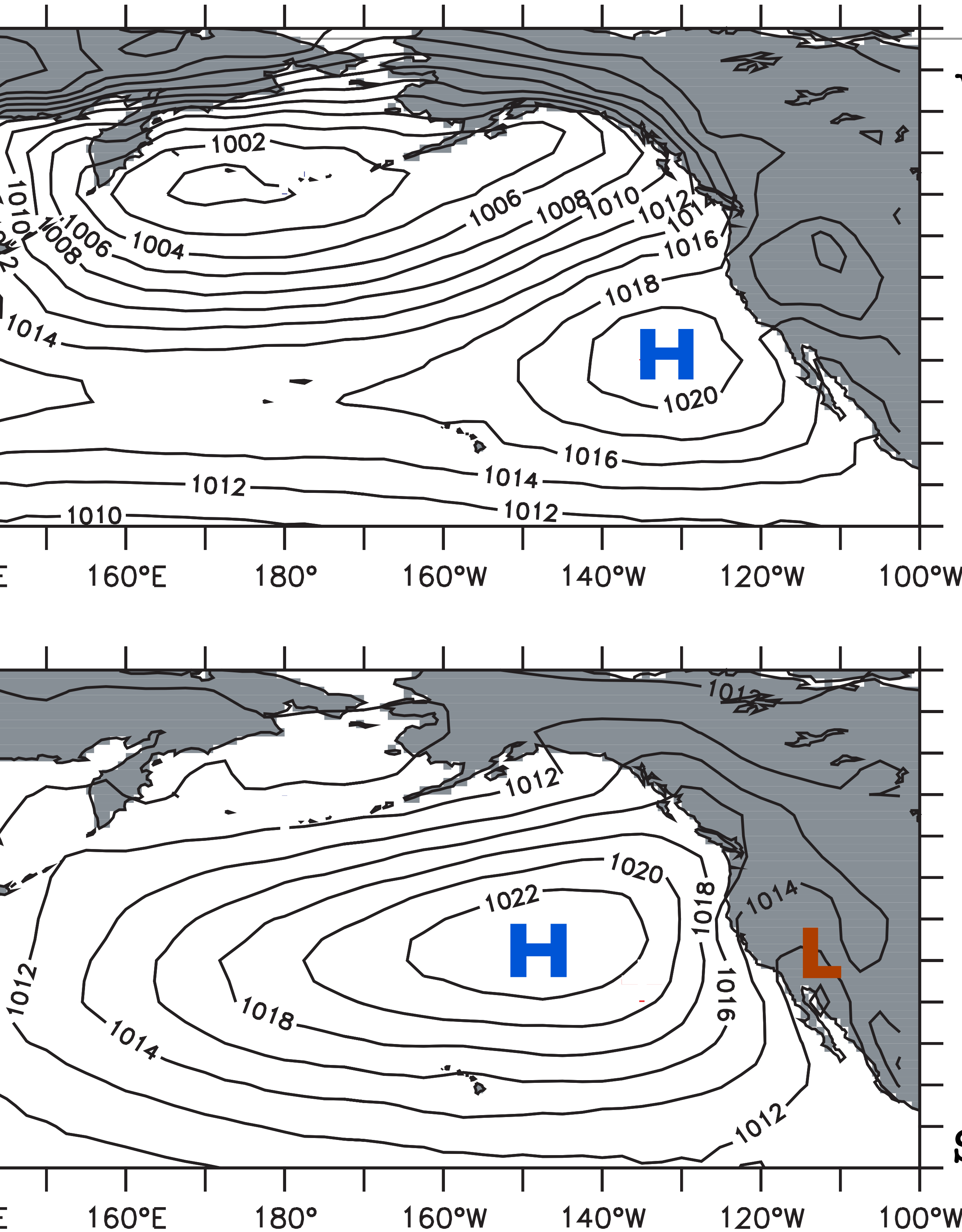
climate indicators driving ecosystem variability

- upwelling: winds and temperature

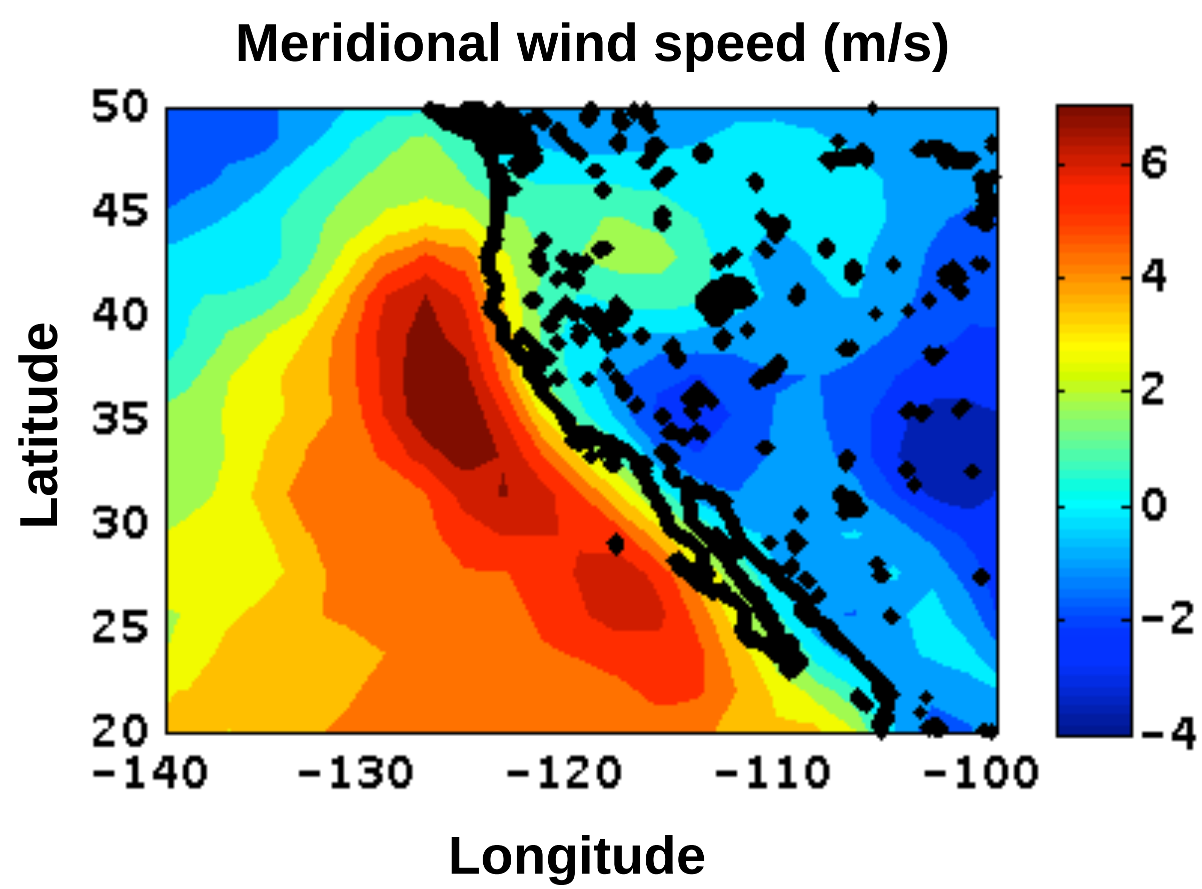
- winter time

upwelling winds driver

winter

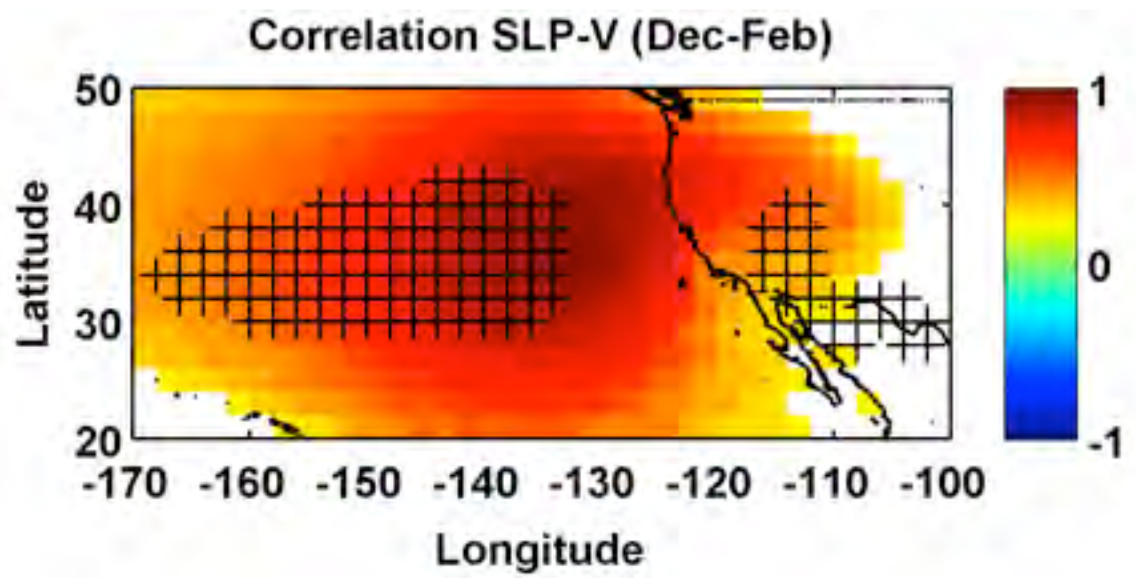


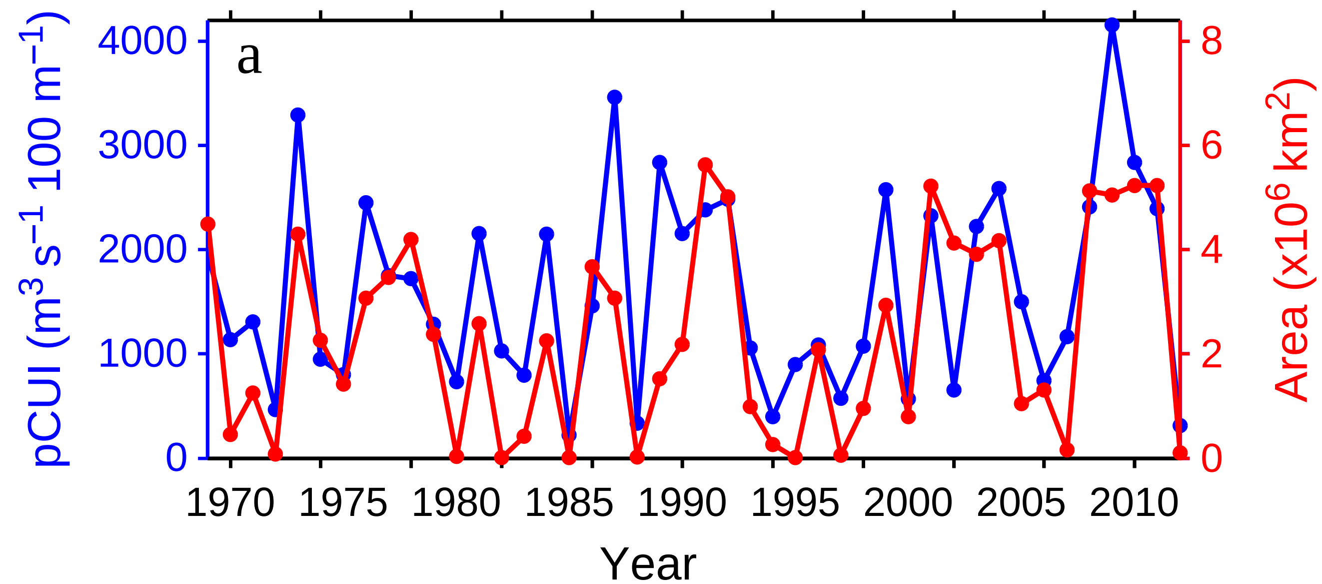
summer



Bograd et al., 2002

winter upwelling and the NPH



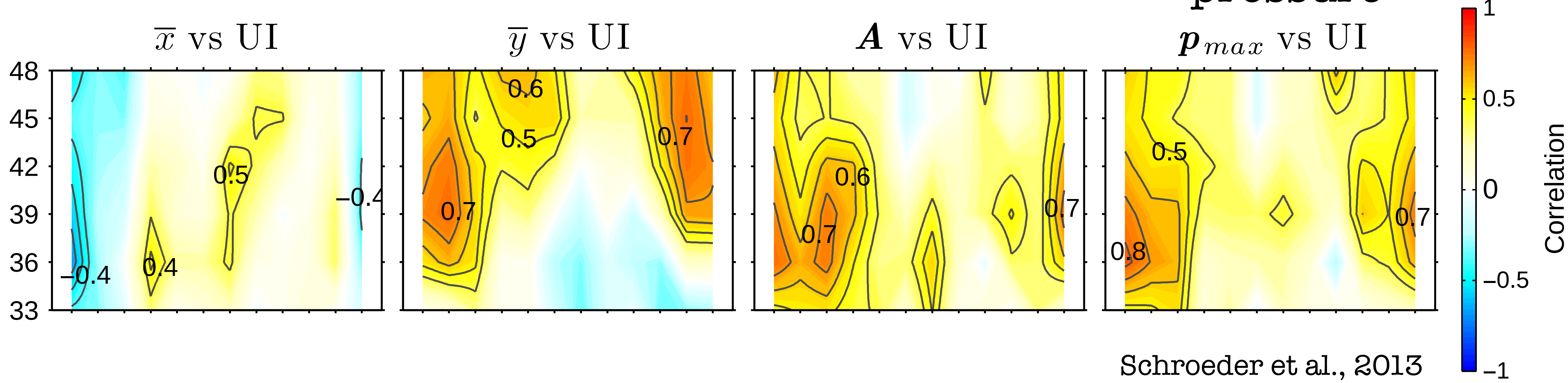


Longitude

Latitude

Area

Maximum pressure



Schroeder et al., 2013

climate indicators driving ecosystem variability

- upwelling: winds and temperature

- winter time

climate indicators driving ecosystem variability

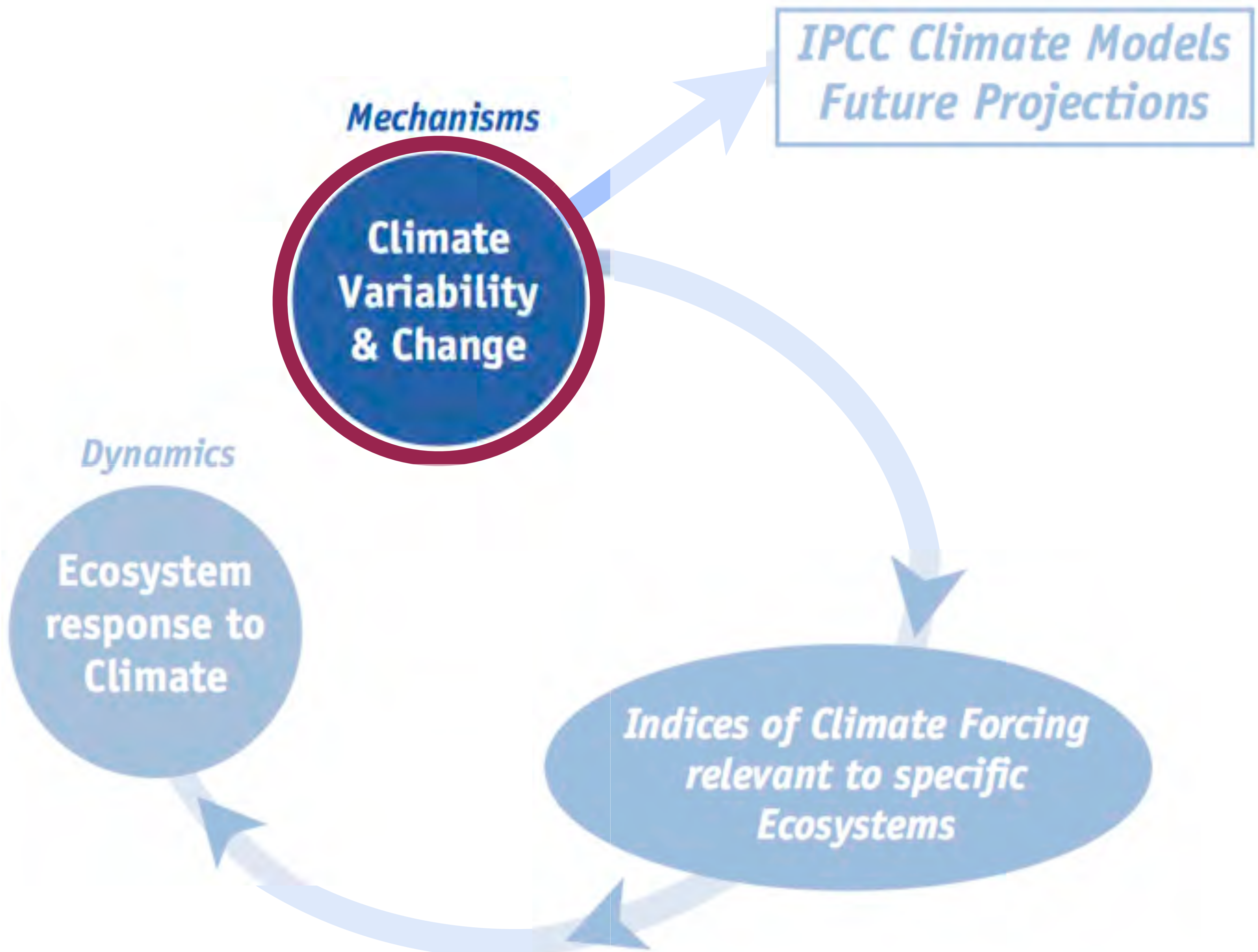
- upwelling: winds ~~and temperature~~

- winter time

climate indicators driving ecosystem variability

- upwelling: winds ~~and temperature~~
    - sea level pressure
- winter time

- spatial and temporal scales adequate for the use of global climate models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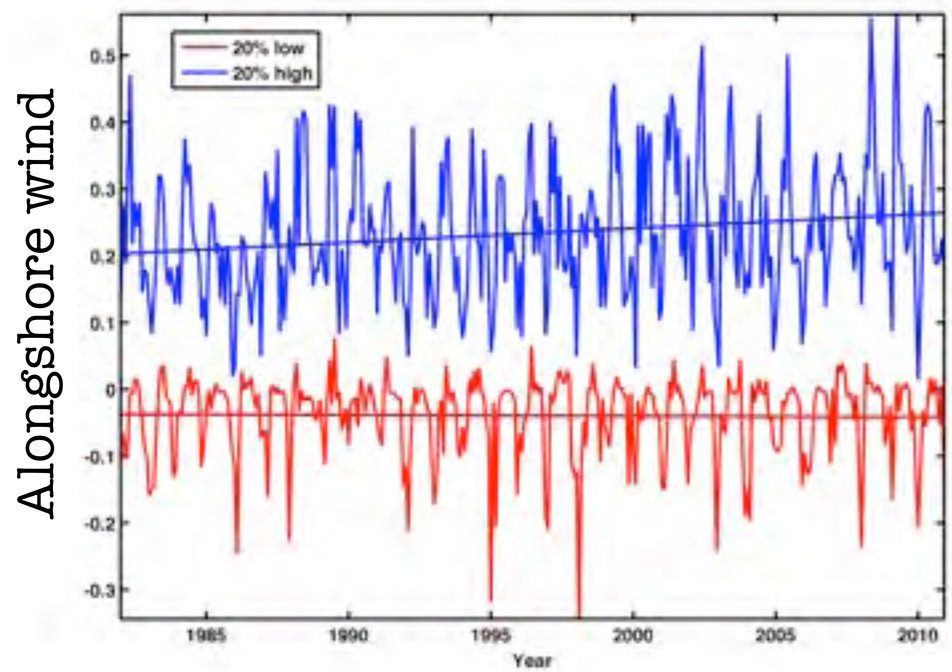
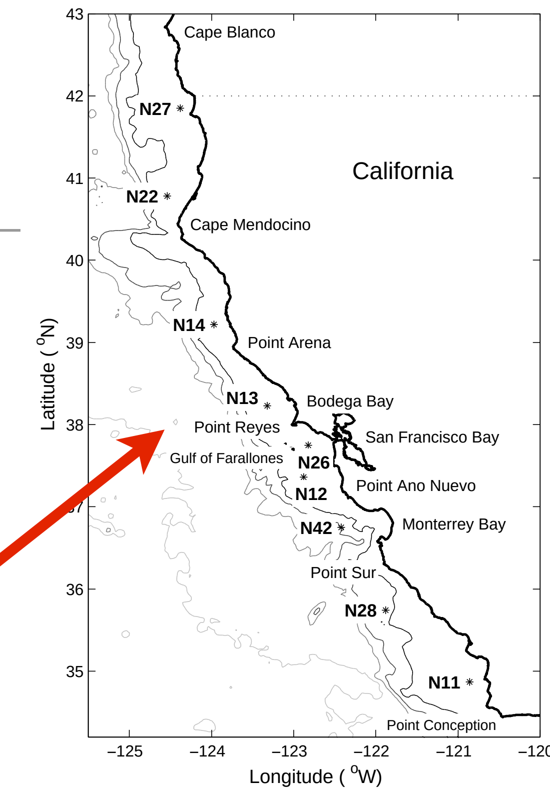
change in variance

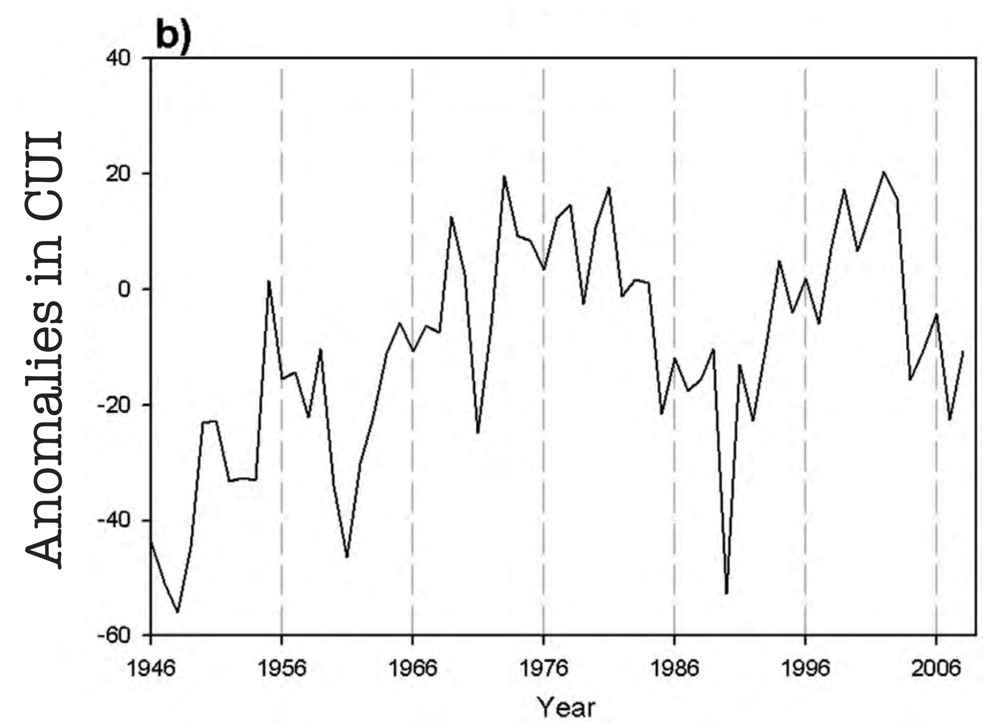
past



García-Reyes & Sydeman. 2012, PICES



future



Macias et al. 2012

mechanism for increased variance unknown

- natural pacific climate oscillations
- anthropogenic climate change
- regional changes

how to test a change in variance

- long time series, with enough temporal resolution

past

future

regional models

local processes

large scale ones are prescribed

global models

global change & large scale processes

no local processes

mechanism for increased variance unknown

- natural pacific climate oscillations
- **anthropogenic climate change**
- regional changes

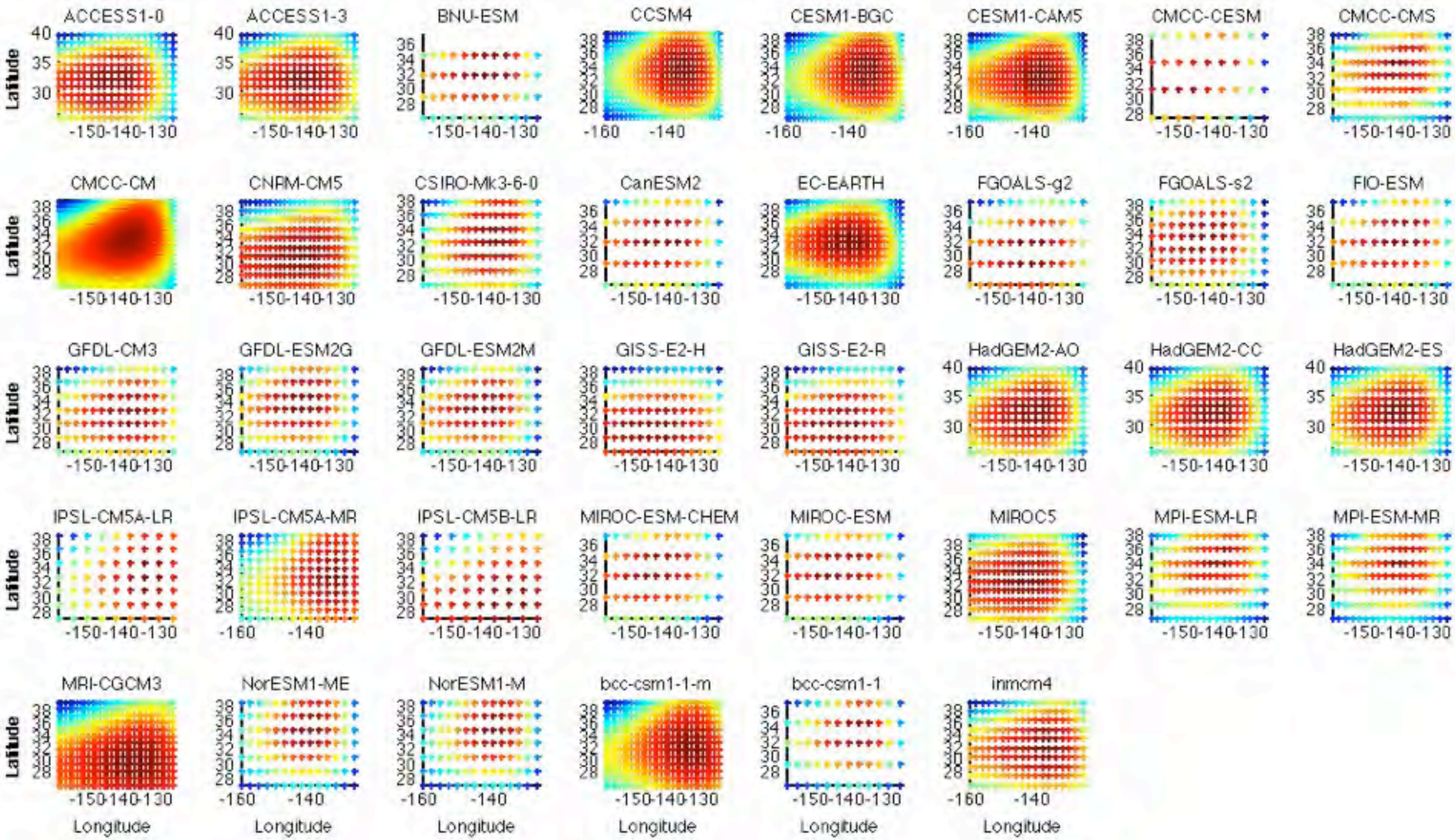
GCM models
IPCC AR5
(CMIP5)

IPCC AR5 - CMIP5

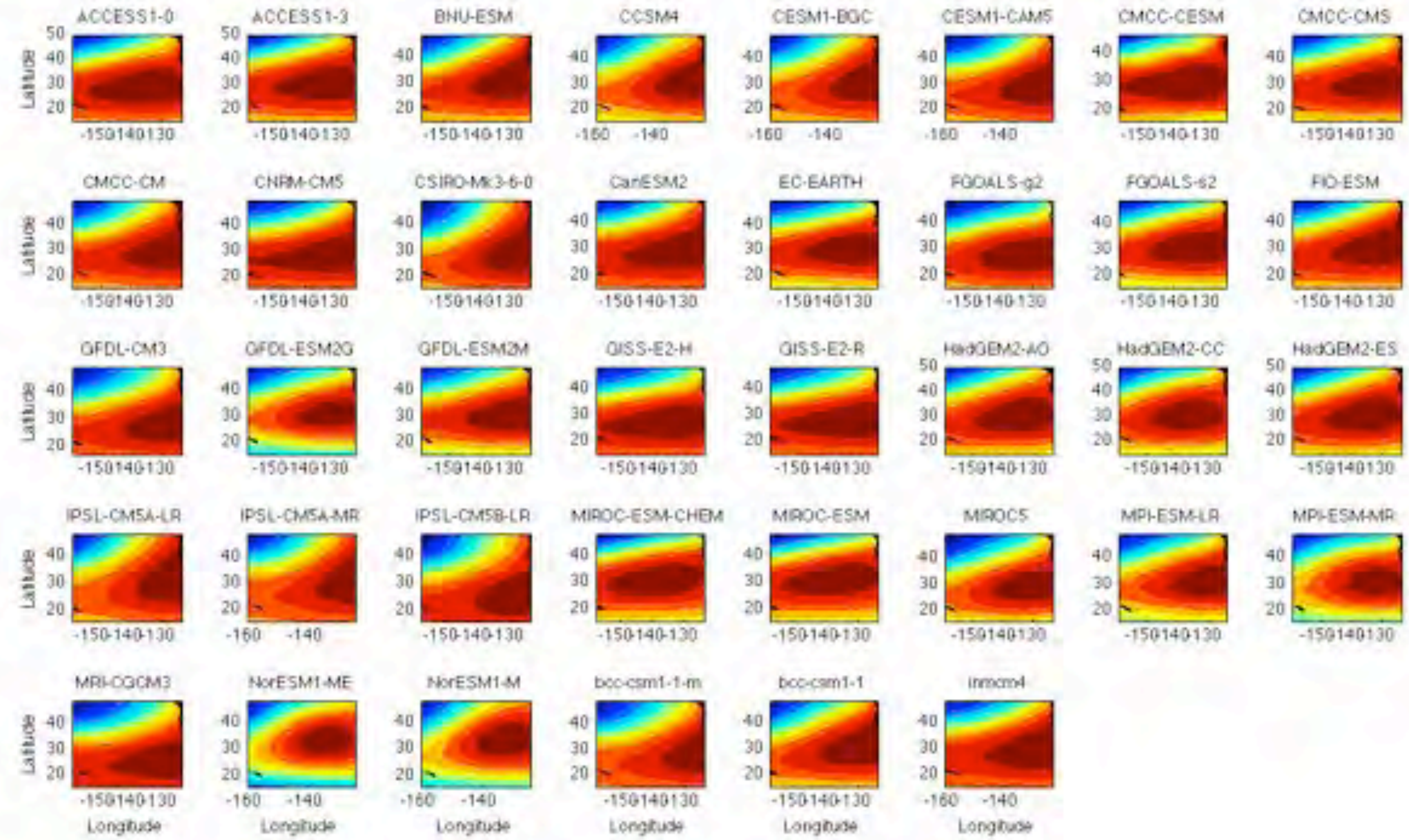
- 38 models output, 21 “different” models
- RCP8.5
- period: 2006-2095

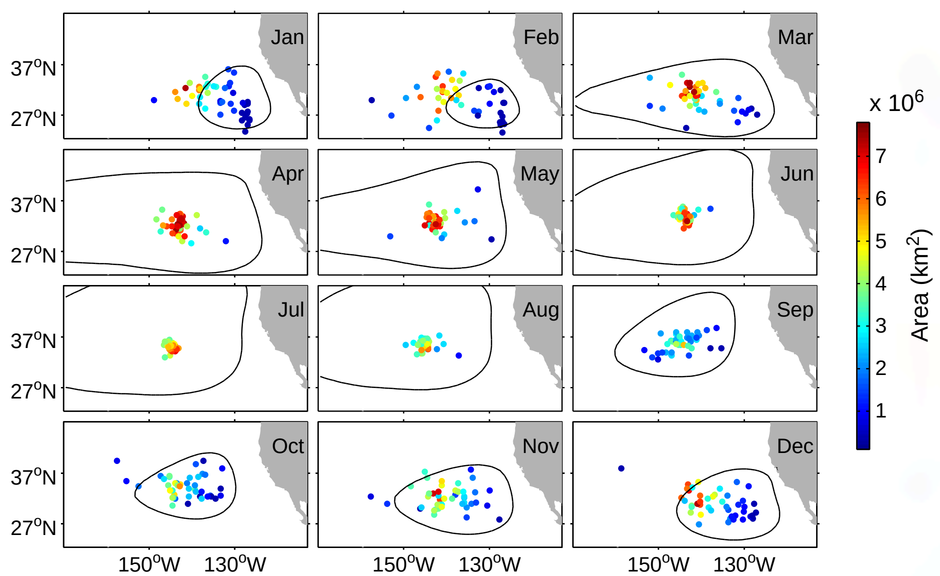
Modeling Center (or Group)	Institute ID	Model Name
Commonwealth Scientific and Industrial Research Organization (CSIRO) and Bureau of Meteorology (BOM), Australia	CSIRO-BOM	ACCESS1.0 ACCESS1.3
Beijing Climate Center, China Meteorological Administration	BCC	BCC-CSM1.1 BCC-CSM1.1(m)
Instituto Nacional de Pesquisas Espaciais (National Institute for Space Research)	INPE	BESM OA 2.3*
College of Global Change and Earth System Science, Beijing Normal University	GCESS	BNU-ESM
Canadian Centre for Climate Modelling and Analysis	CCCMA	CanESM2 CanCM4 CanAM4
University of Miami - RSMAS	RSMAS	CCSM4(RSMAS)*
National Center for Atmospheric Research	NCAR	CCSM4
Community Earth System Model Contributors	NSF-DOE-NCAR	CESM1(BGC) CESM1(CAM5) CESM1(CAM5.1,FV2) CESM1(FASTCHEM) CESM1(WACCM)
Center for Ocean-Land-Atmosphere Studies and National Centers for Environmental Prediction	COLA and NCEP	CFSv2-2011
Centro Euro-Mediterraneo per I Cambiamenti Climatici	CMCC	CMCC-CESM CMCC-CM CMCC-CMS
Centre National de Recherches Météorologiques / Centre Européen de Recherche et Formation Avancée en Calcul Scientifique	CNRM-CERFACS	CNRM-CM5 CNRM-CM5-2
Commonwealth Scientific and Industrial Research Organization in collaboration with Queensland Climate Change Centre of Excellence	CSIRO-QCCCE	CSIRO-Mk3.6.0
EC-EARTH consortium	EC-EARTH	EC-EARTH
LASG, Institute of Atmospheric Physics, Chinese Academy of Sciences and CESS,Tsinghua University	LASG-CESS	FGOALS-g2
LASG, Institute of Atmospheric Physics, Chinese Academy of Sciences	LASG-IAP	FGOALS-gl FGOALS-s2
The First Institute of Oceanography, SOA, China	FIO	FIO-ESM
NASA Global Modeling and Assimilation Office	NASA GMAO	GEOS-5
NOAA Geophysical Fluid Dynamics Laboratory	NOAA GFDL	GFDL-CM2.1 GFDL-CM3 GFDL-ESM2G GFDL-ESM2M GFDL-HIRAM-C180 GFDL-HIRAM-C360
NASA Goddard Institute for Space Studies	NASA GISS	GISS-E2-H GISS-E2-H-CC GISS-E2-R GISS-E2-R-CC
National Institute of Meteorological Research/Korea Meteorological Administration	NIMR/KMA	HadGEM2-AO
Met Office Hadley Centre (additional HadGEM2-ES realizations contributed by Instituto Nacional de Pesquisas Espaciais)	MOHC (additional realizations by INPE)	HadCM3 HadGEM2-CC HadGEM2-ES HadGEM2-A
Institute for Numerical Mathematics	INM	INM-CM4
Institut Pierre-Simon Laplace	IPSL	IPSL-CM5A-LR IPSL-CM5A-MR IPSL-CM5B-LR
Japan Agency for Marine-Earth Science and Technology, Atmosphere and Ocean Research Institute (The University of Tokyo), and National Institute for Environmental Studies	MIROC	MIROC-ESM MIROC-ESM-CHEM
Atmosphere and Ocean Research Institute (The University of Tokyo), National Institute for Environmental Studies, and Japan Agency for Marine-Earth Science and Technology	MIROC	MIROC4h MIROC5
Max-Planck-Institut für Meteorologie (Max Planck Institute for Meteorology)	MPI-M	MPI-ESM-MR MPI-ESM-LR MPI-ESM-P
Meteorological Research Institute	MRI	MRI-AGCM3.2H MRI-AGCM3.2S MRI-CGCM3 MRI-ESM1
Nonhydrostatic Icosahedral Atmospheric Model Group	NICAM	NICAM.09
Norwegian Climate Centre	NCC	NorESM1-M NorESM1-ME

CMIP5 models resolution



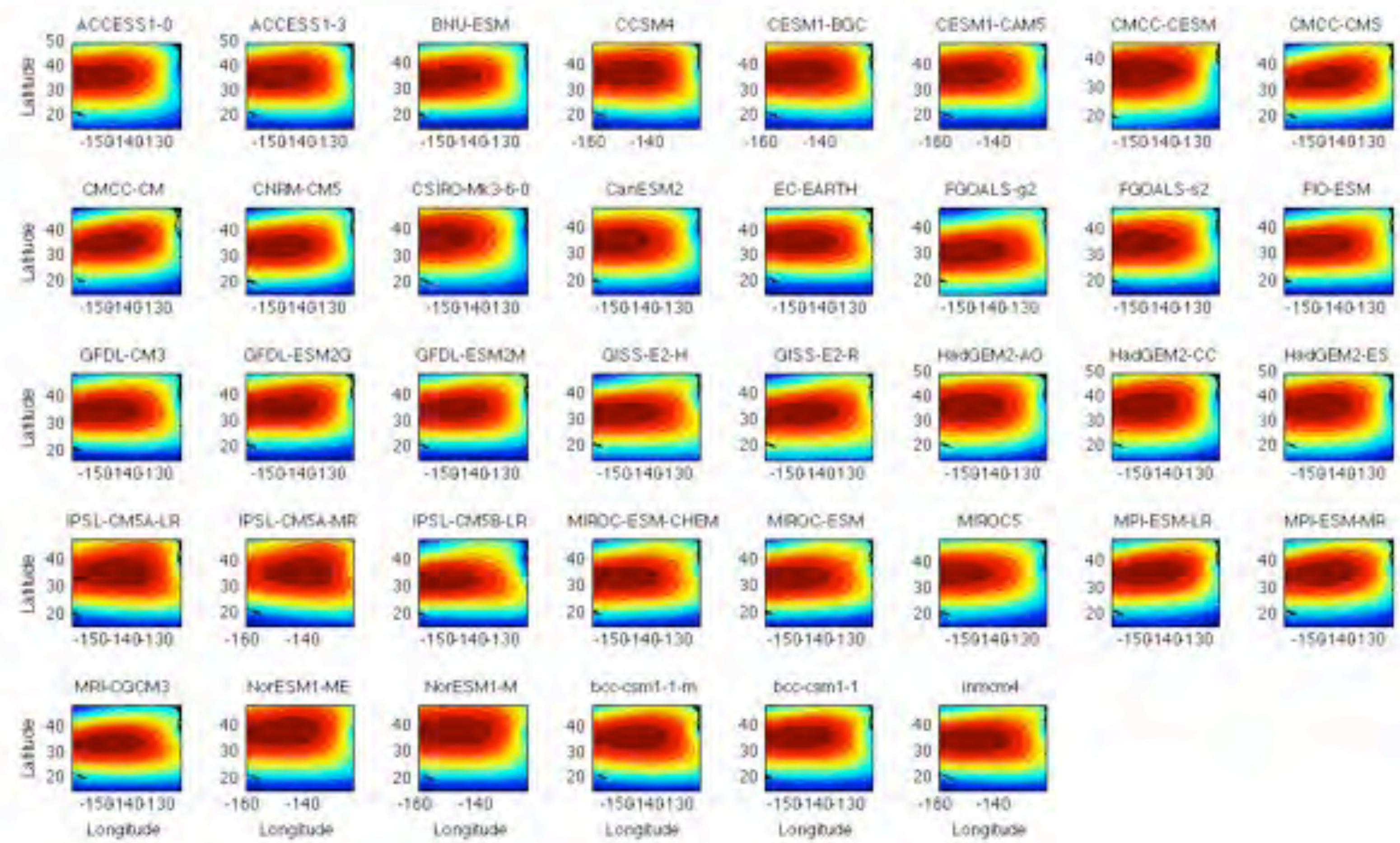
Dec-Feb



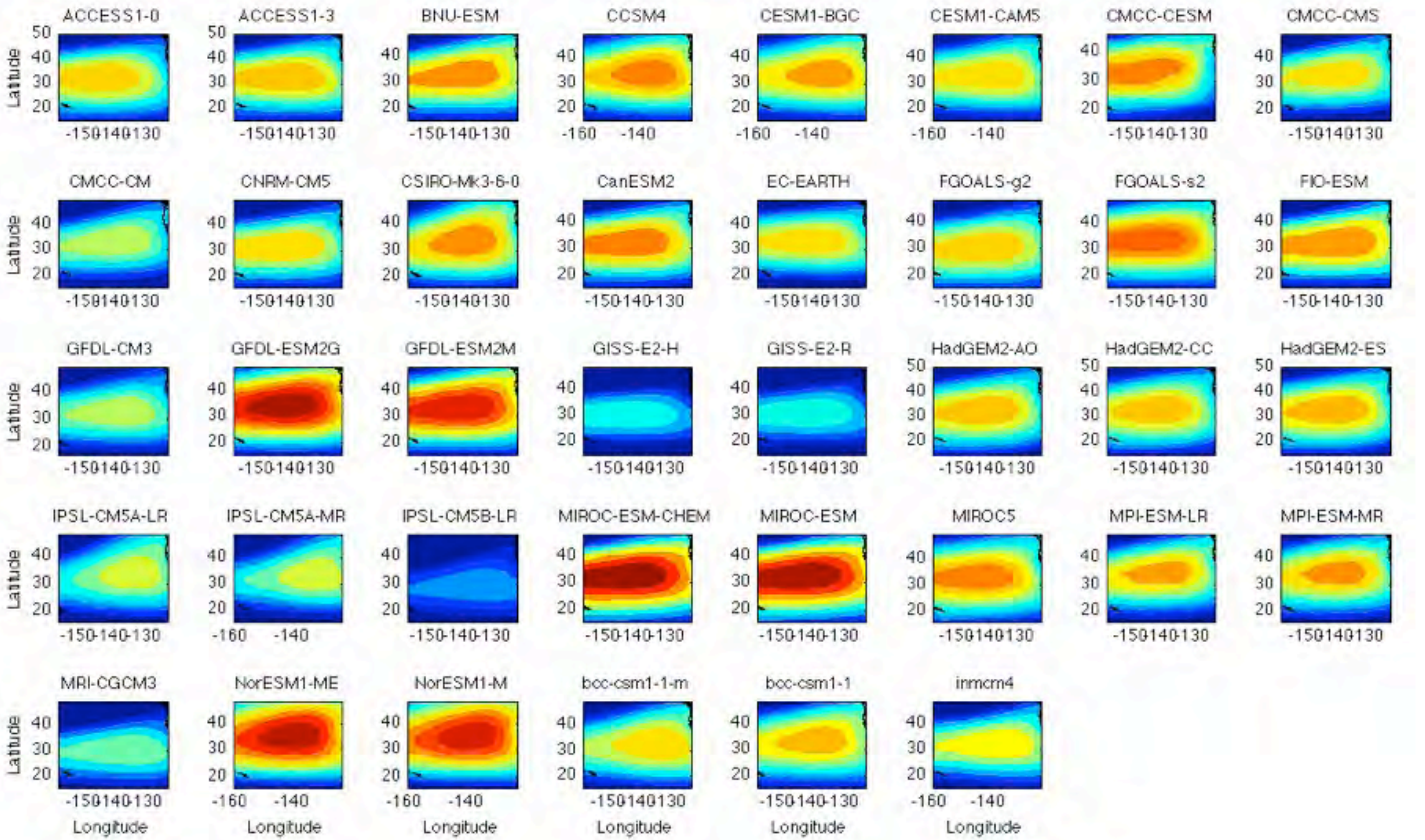


Schroeder et al. 2013

Apr-Aug



not all models are made equal



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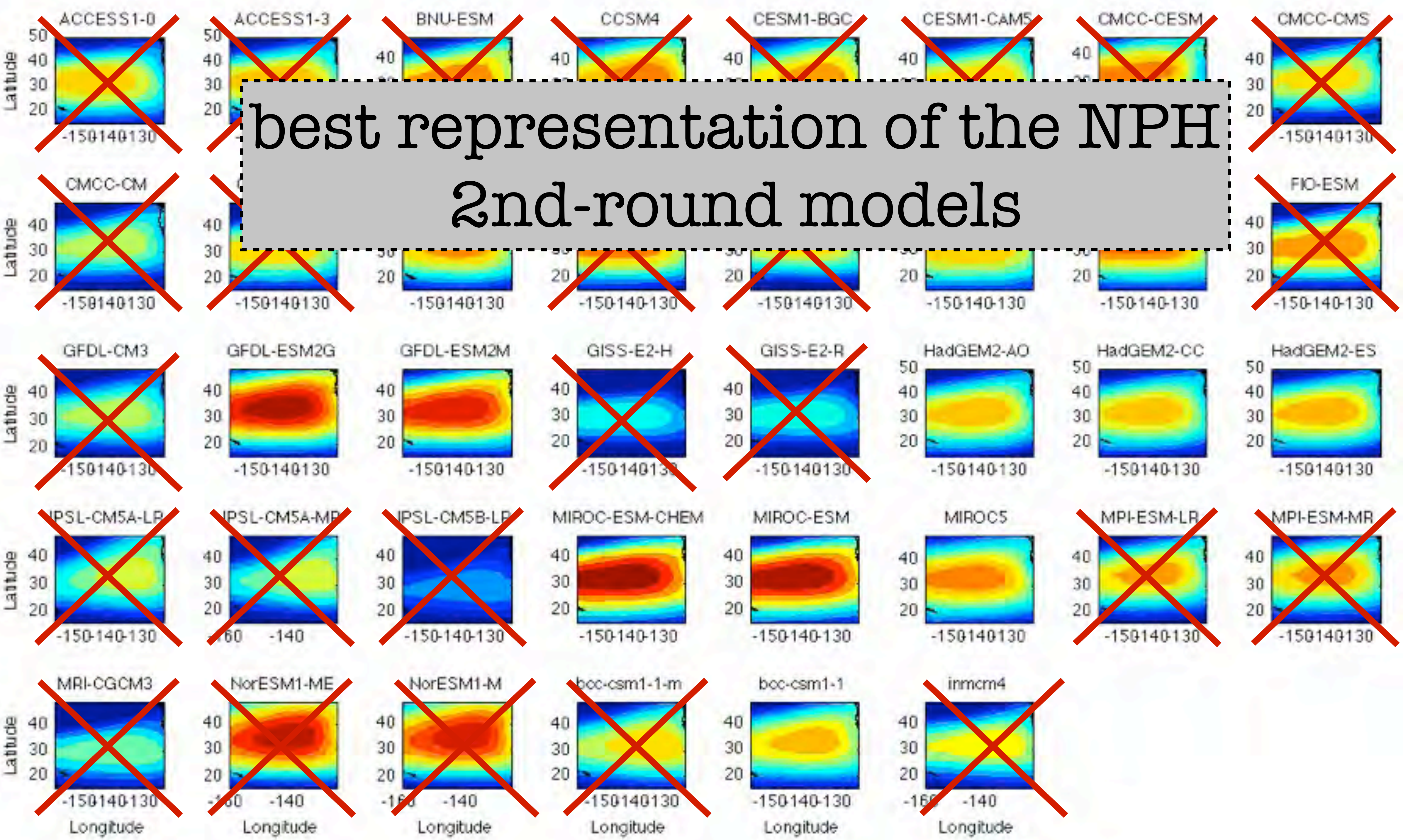
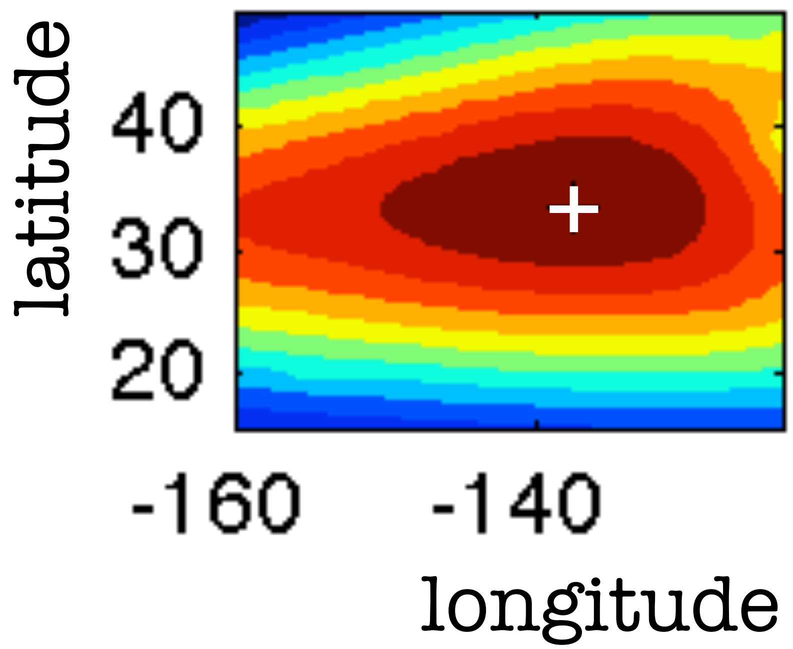


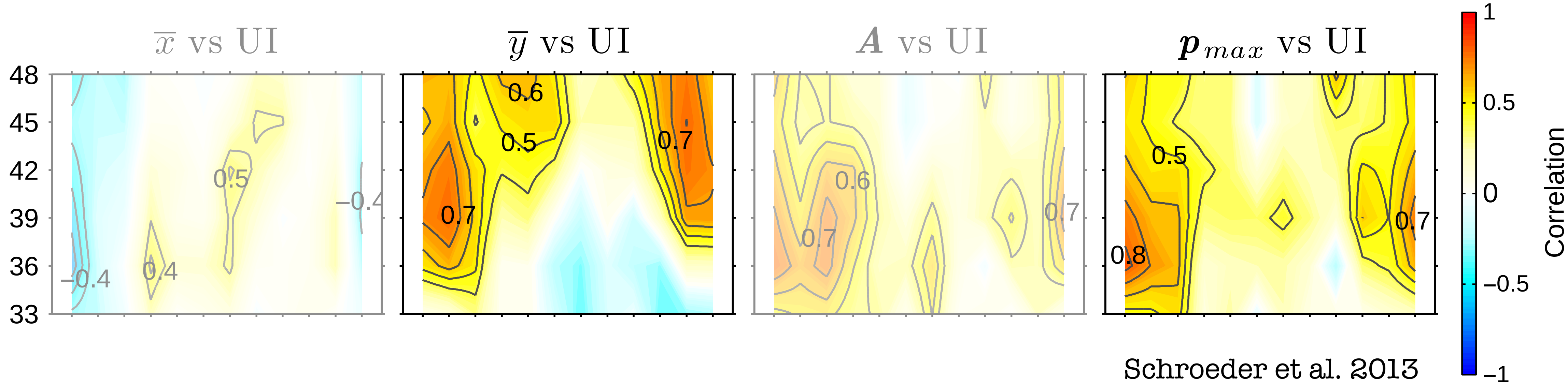
best representation of the NPH
2nd-round models

parameters



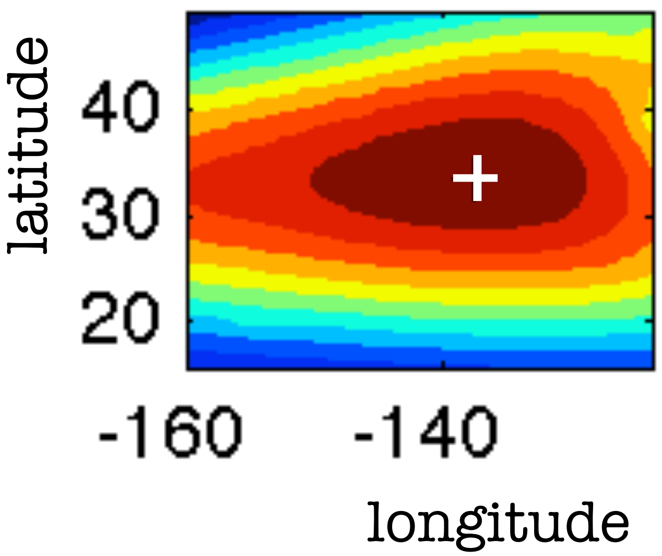
maximum SLP

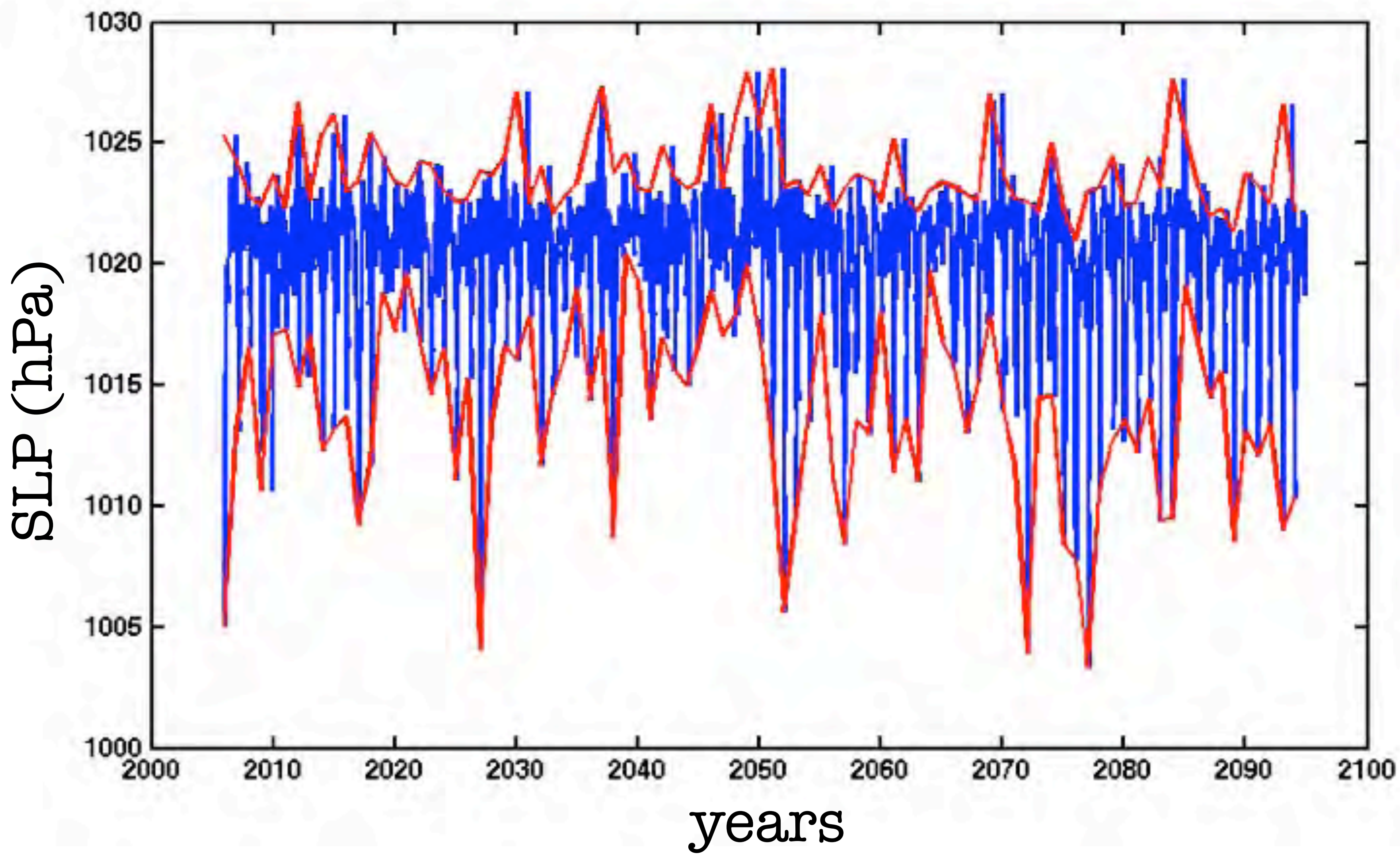
latitude of maximum SLP



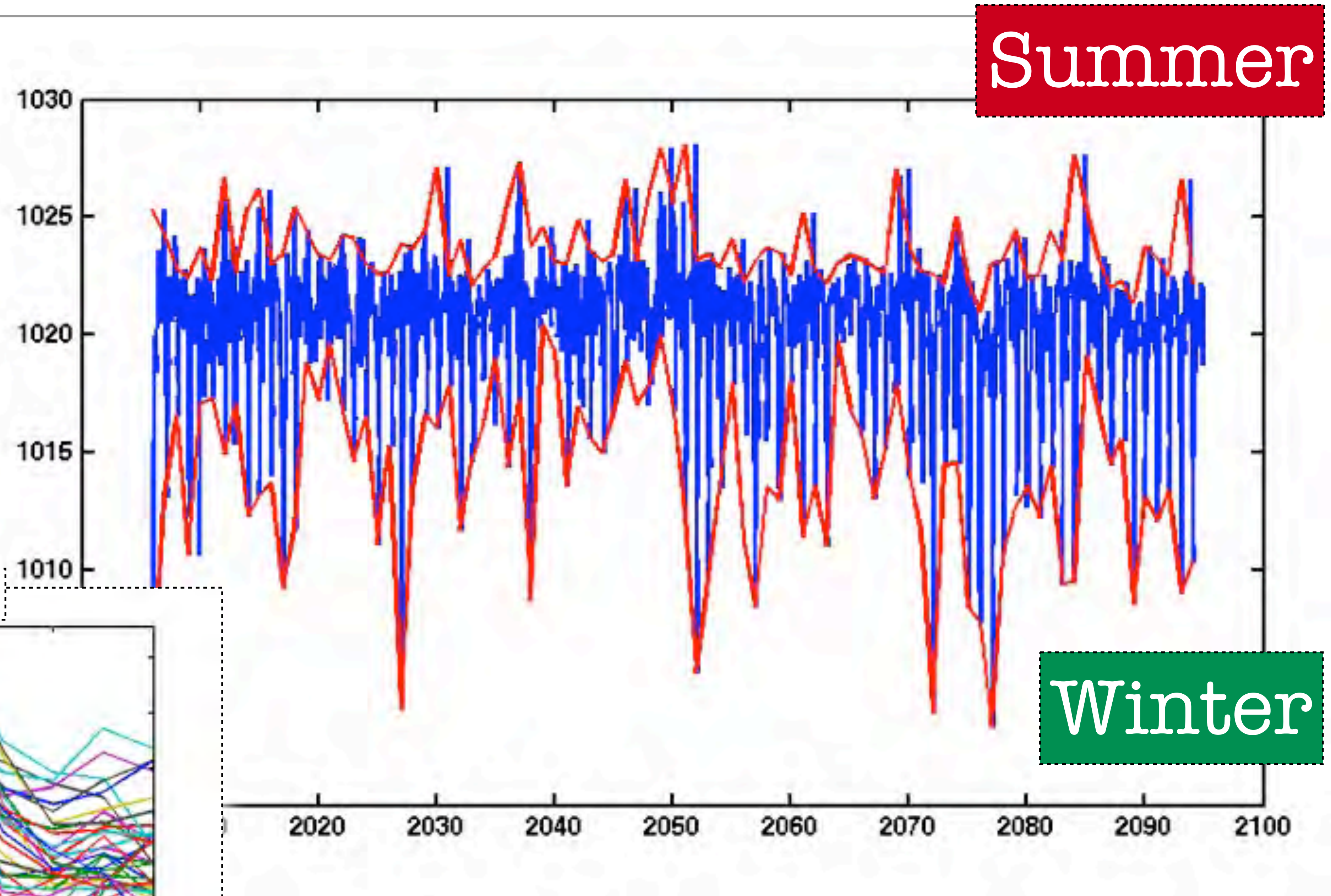
Schroeder et al. 2013

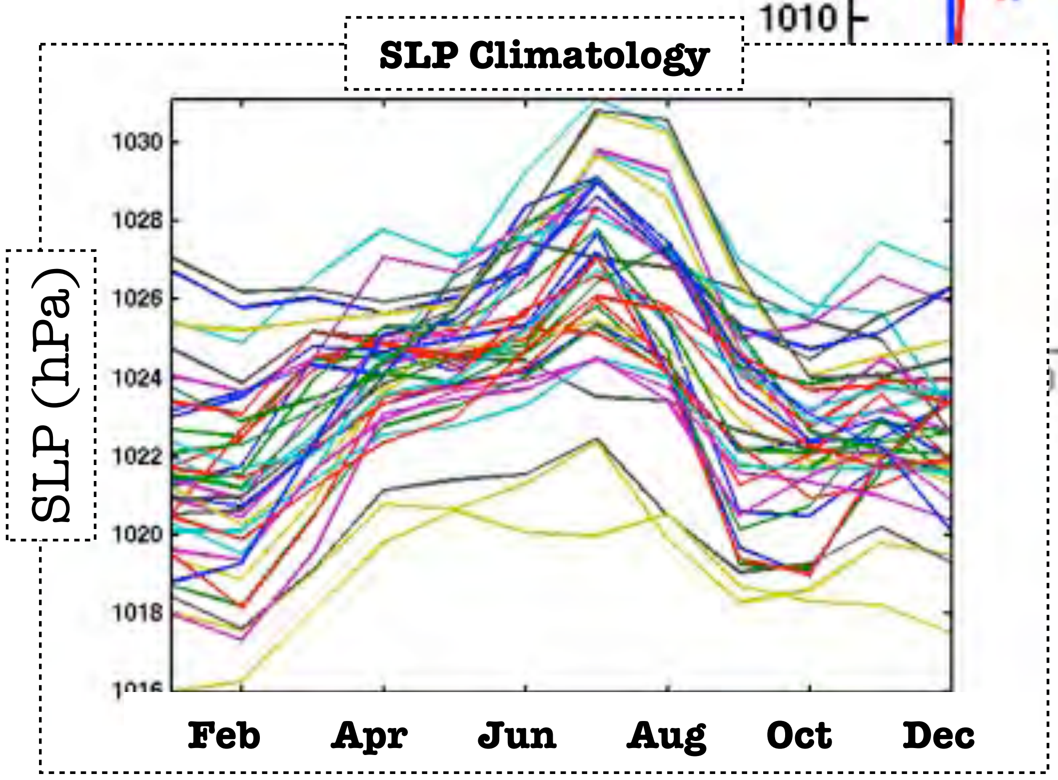
Maximum SLP over NPH region





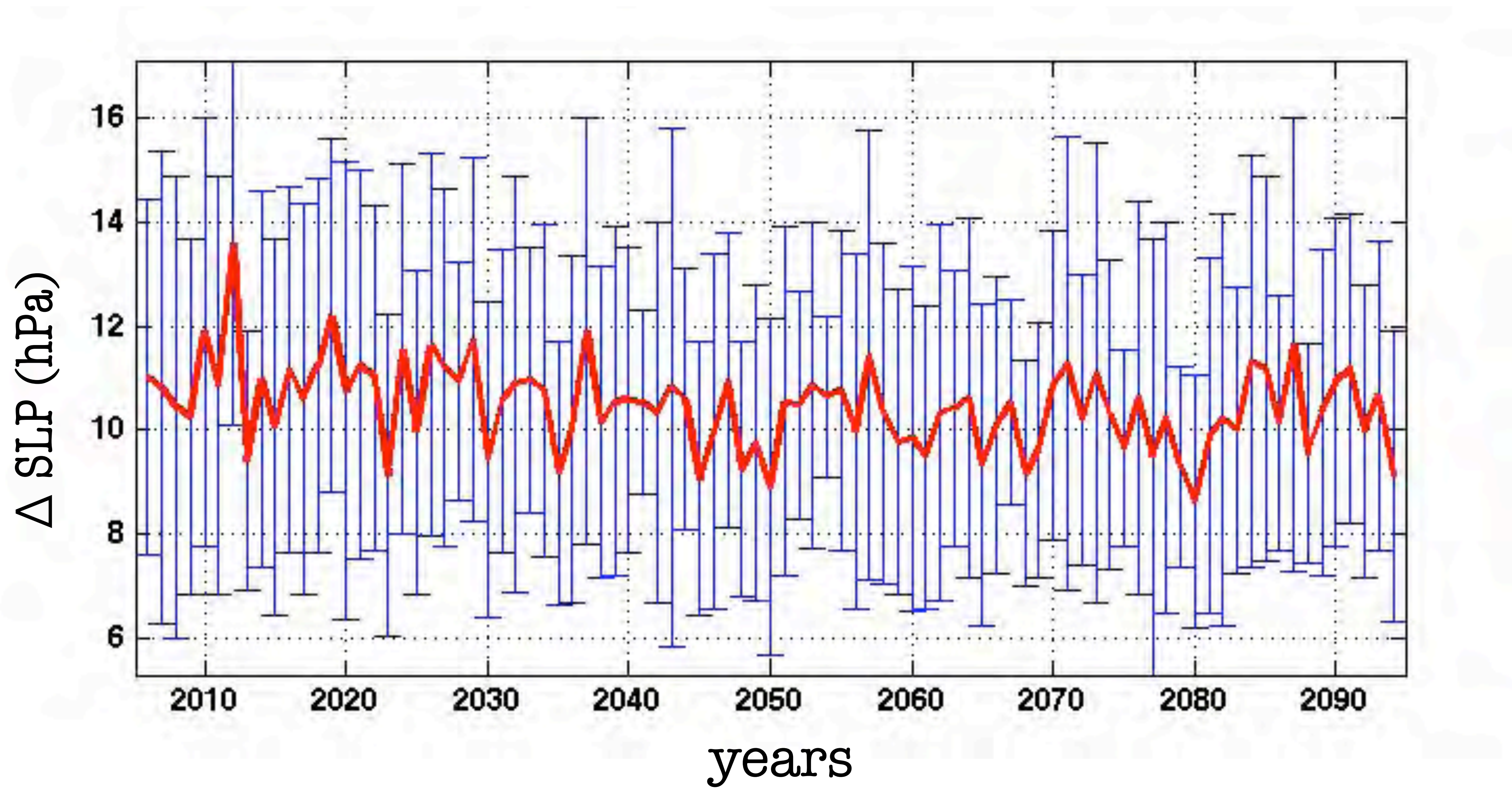
Maximum SLP over NPH region





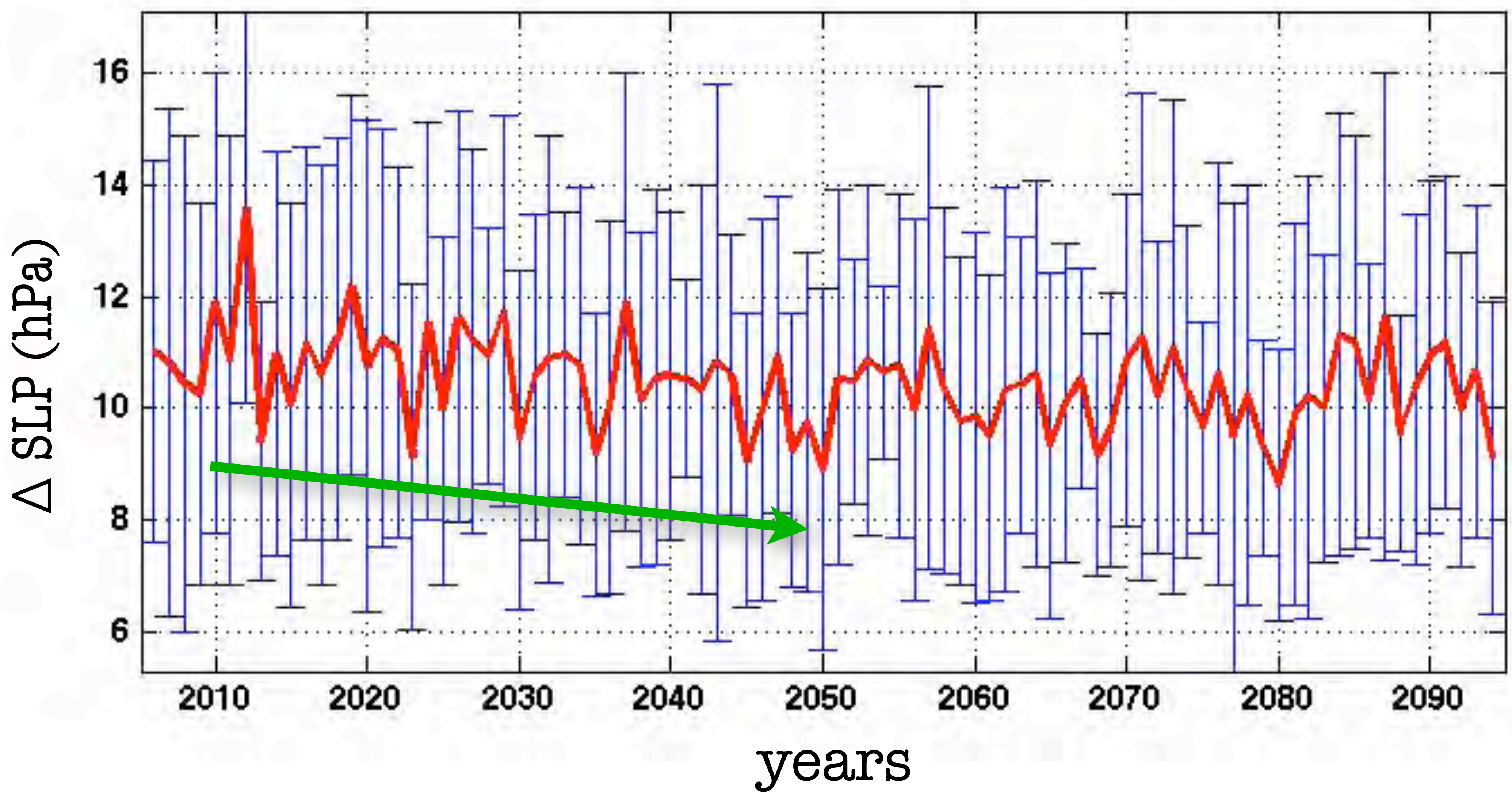
Difference Maximum and Minimum SLP

Models ensemble



Difference Maximum and Minimum SLP

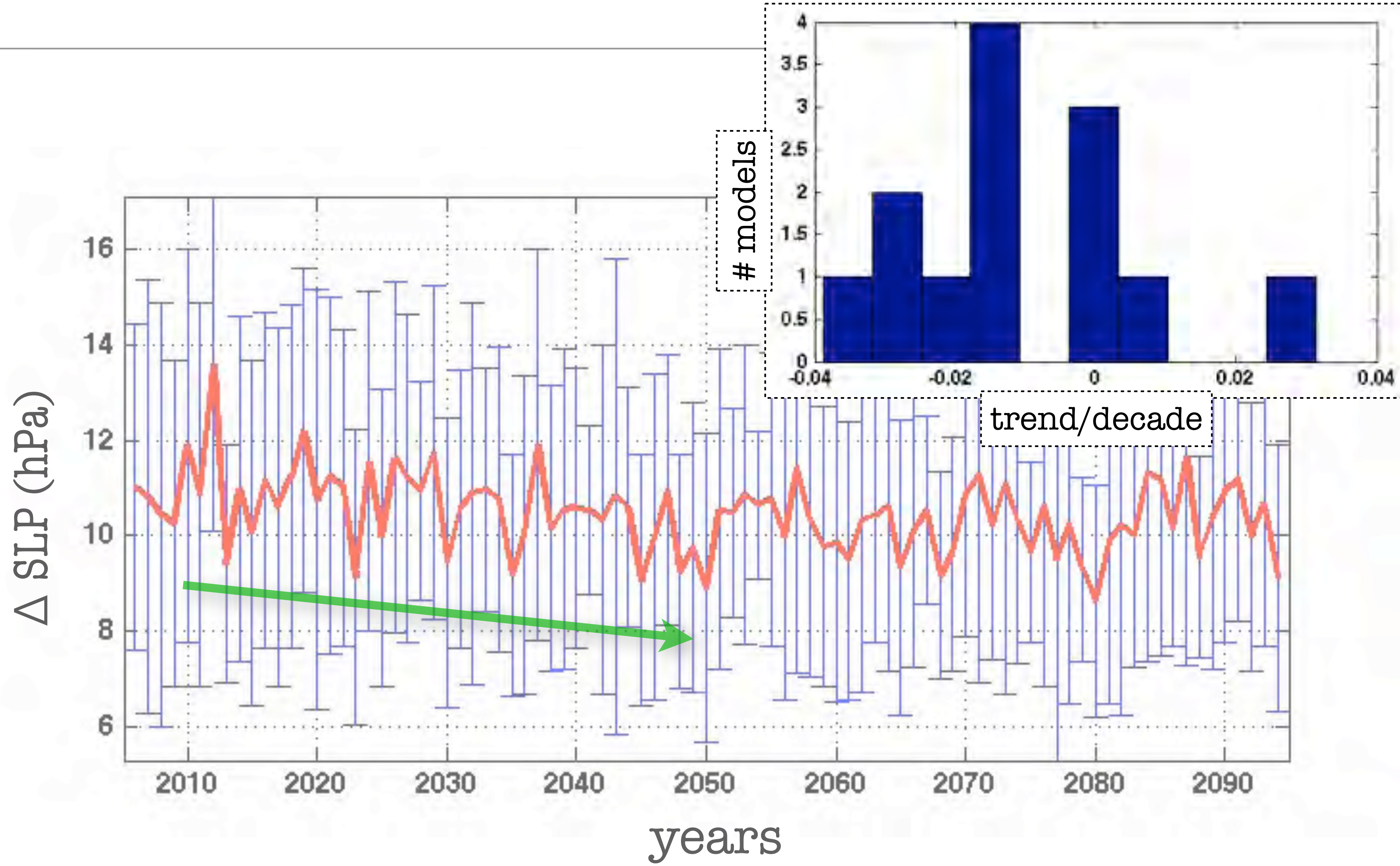
Models ensemble



-0.1hPa/decade

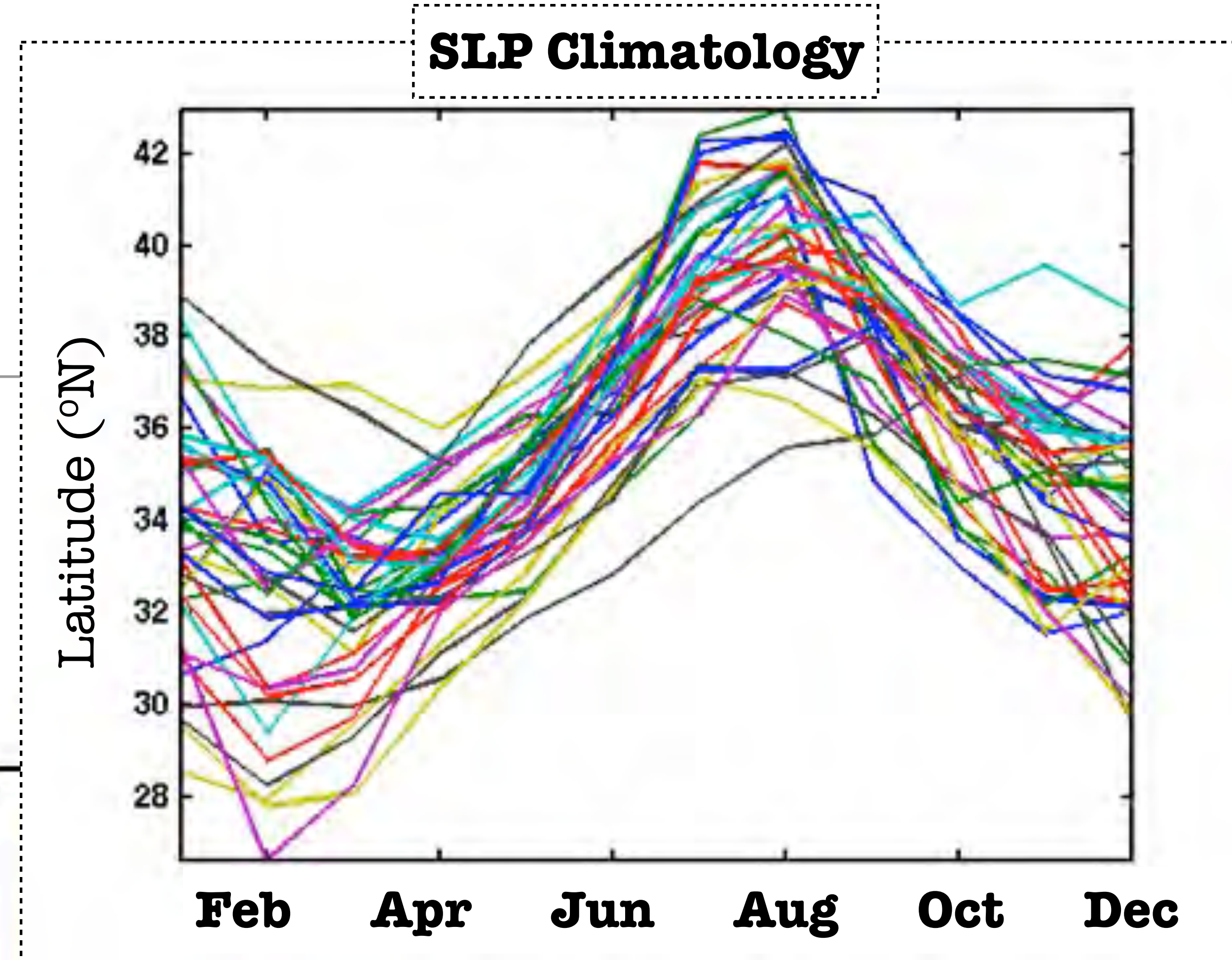
Difference Maximum and Minimum SLP

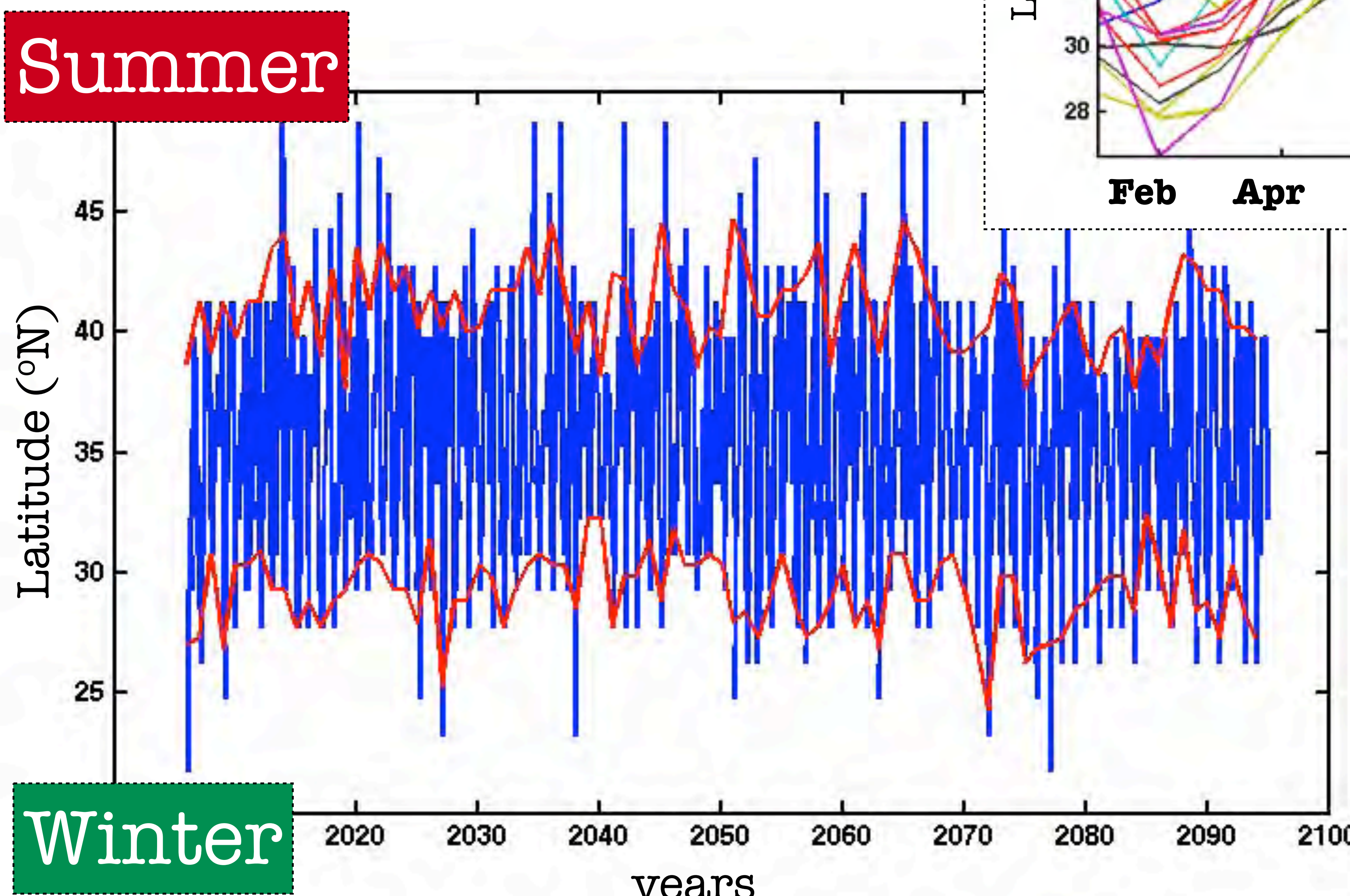
Models ensemble

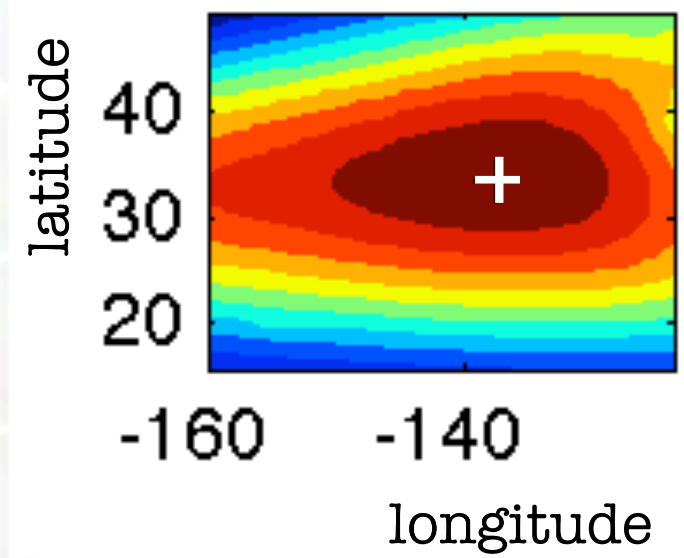


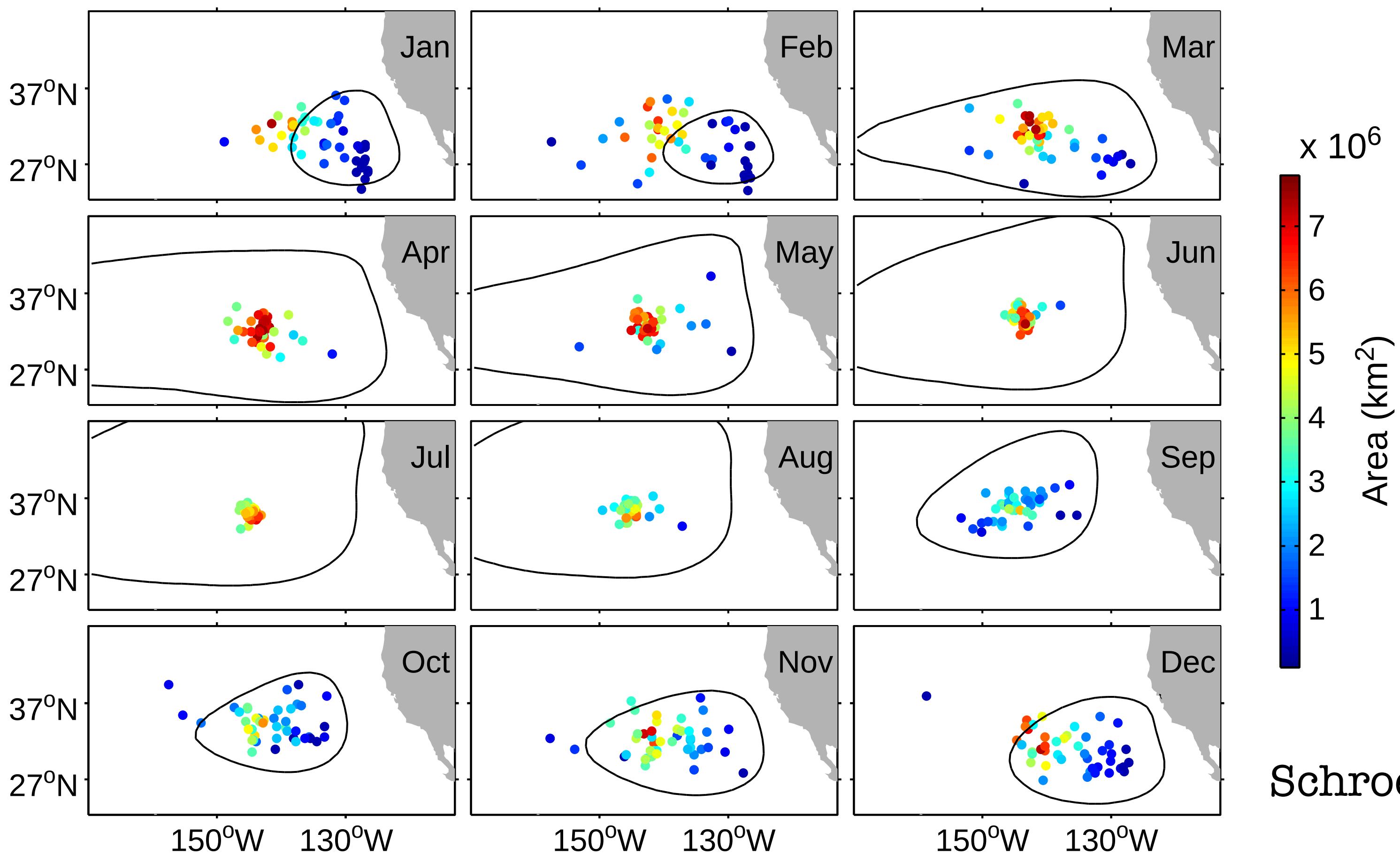
-0.1hPa/decade

Latitude of Maximum SLP

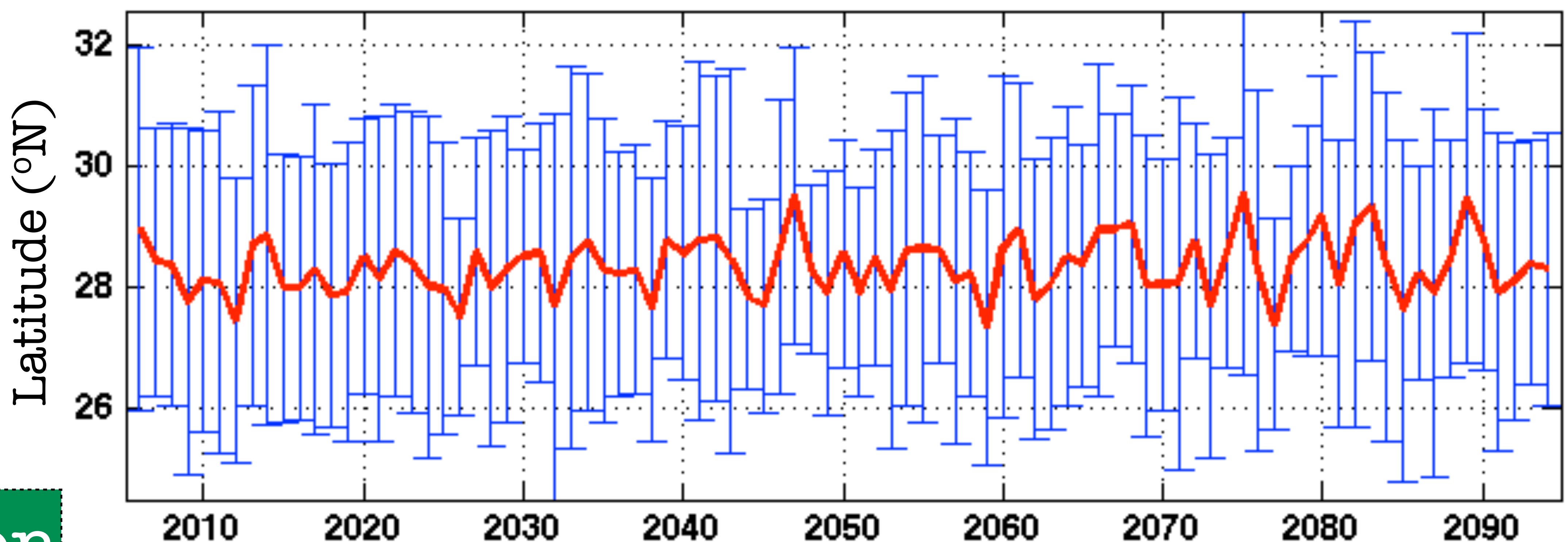




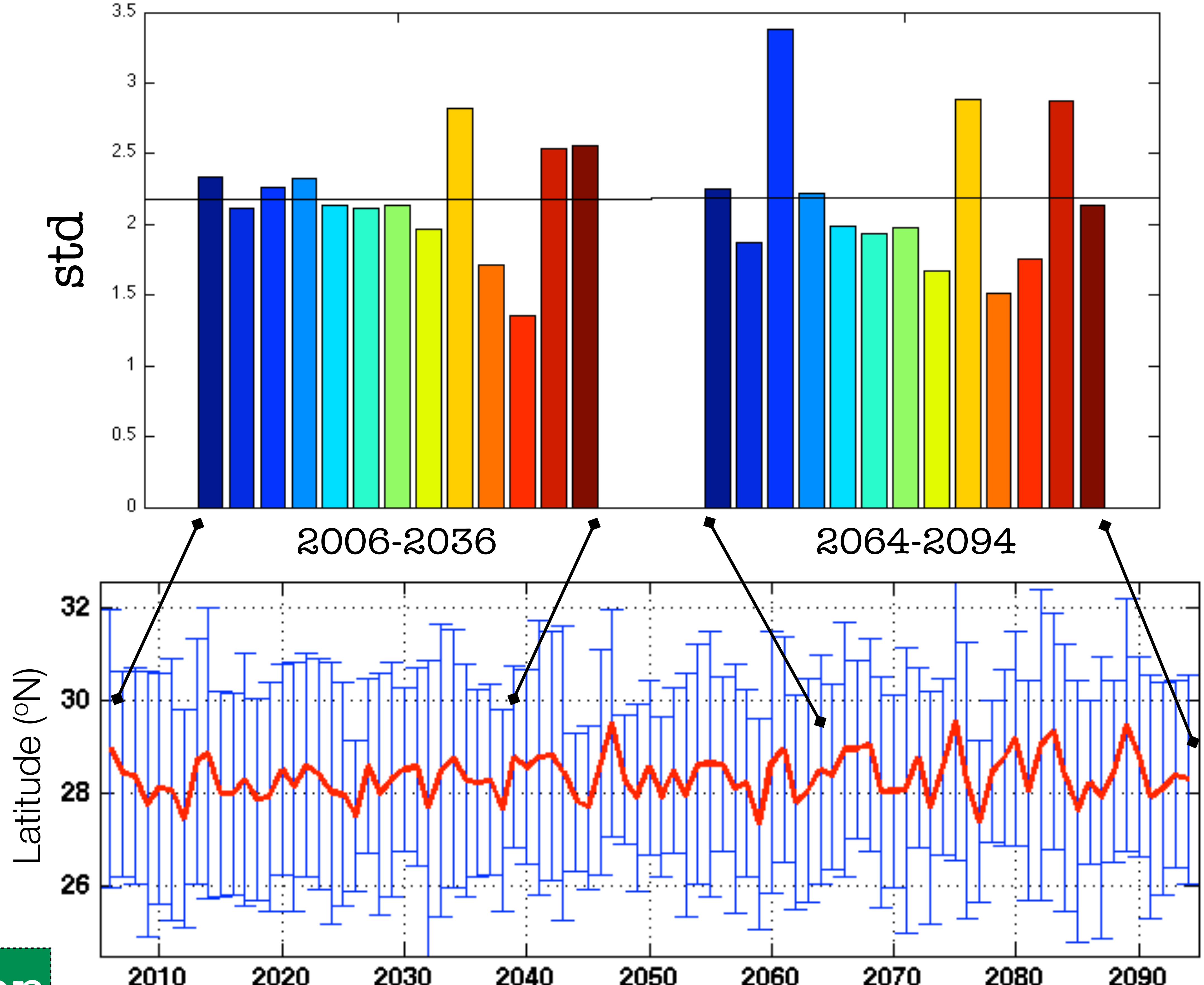




Schroeder et al. 2013



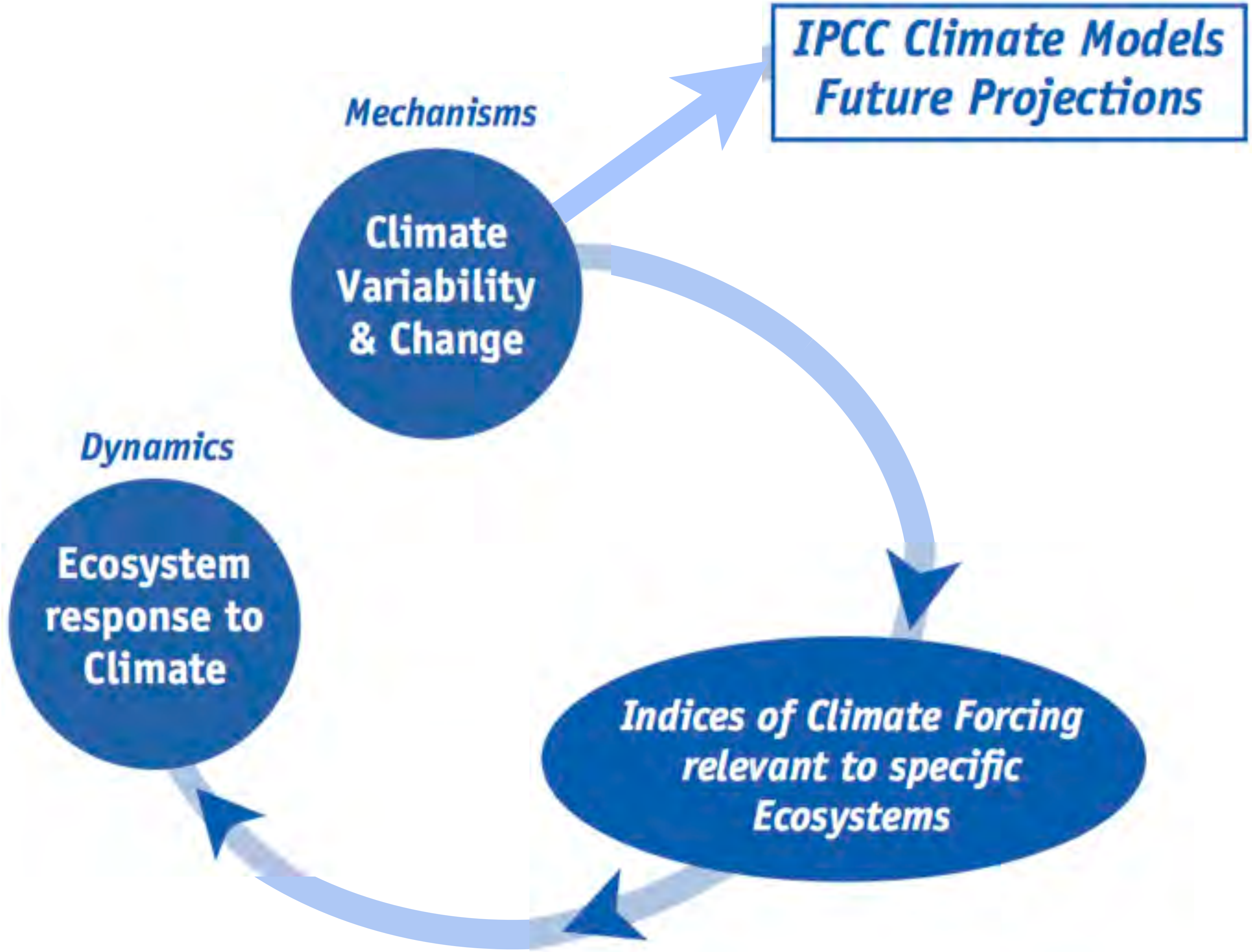
Winter



std
3.5
3
2.5
2
1.5
1
0.5
0
2006-2036
2064-2094
Latitude (°N)
32
30
28
26
2010
2020
2030
2040
2050
2060
2070
2080
2090

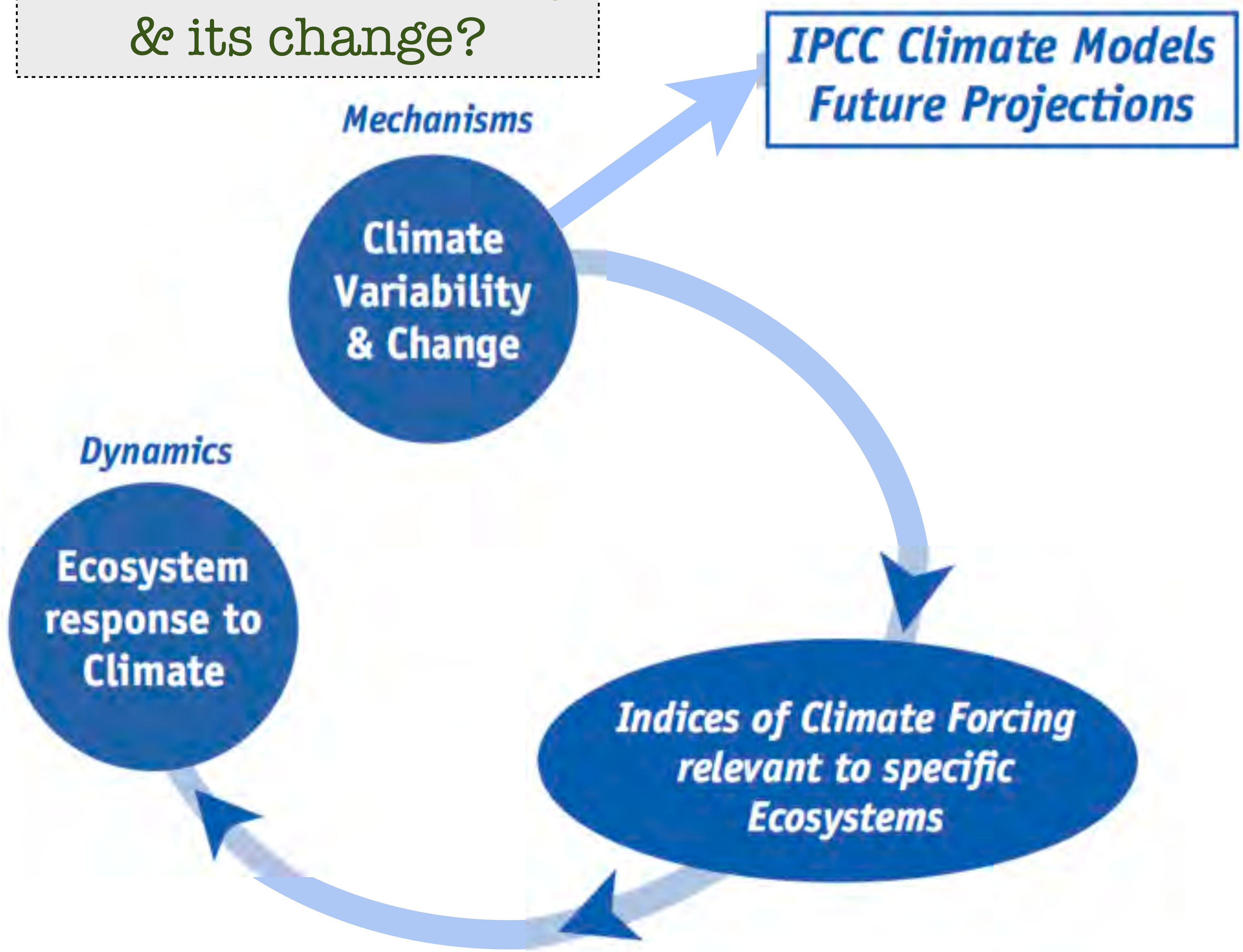
Winter

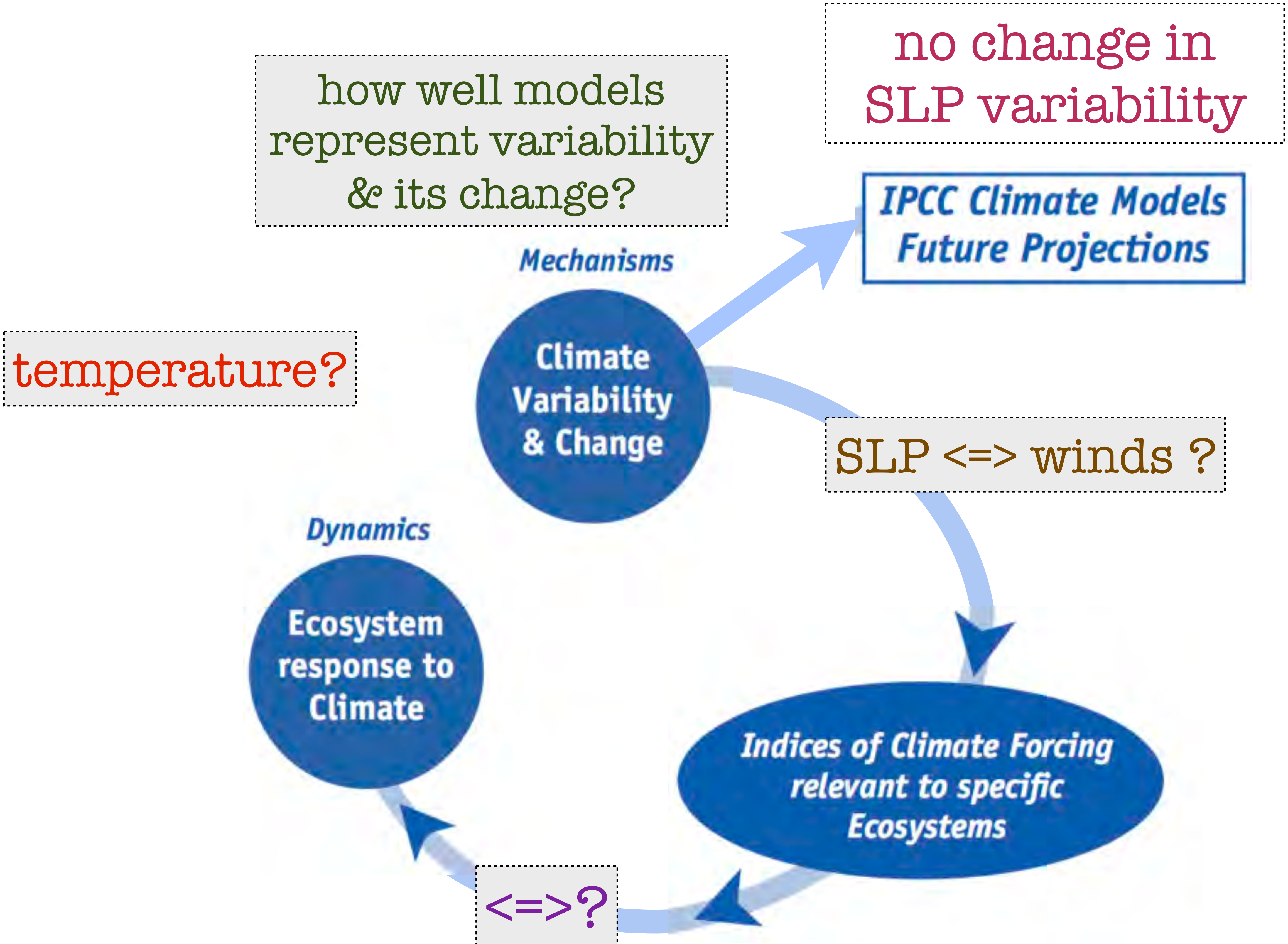
no change in
SLP variability



how well models represent variability & its change?

no change in SLP variability

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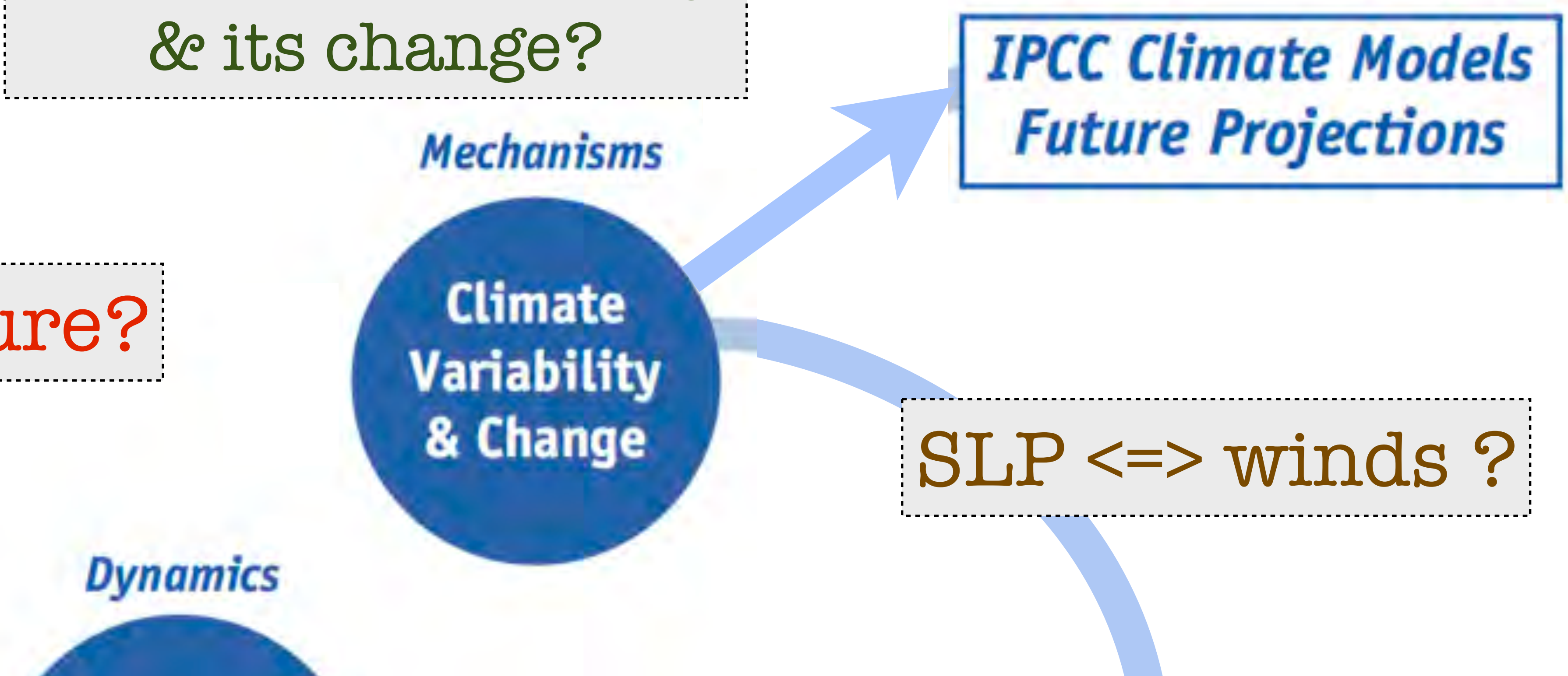

temperature?

SLP <=> winds ?

- is lack of change or models' skill?
- match with observed increasing variability in winds?
- ensemble method appropriate?