Climate Model Performance for Regional Ecosystem Projections

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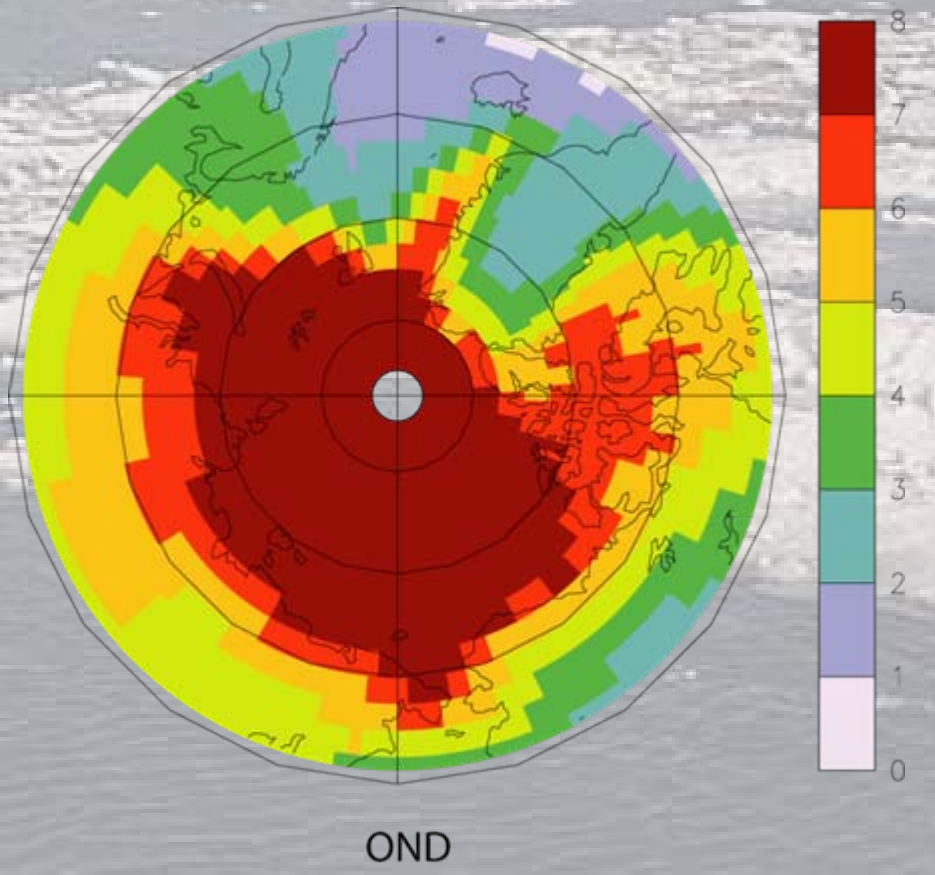
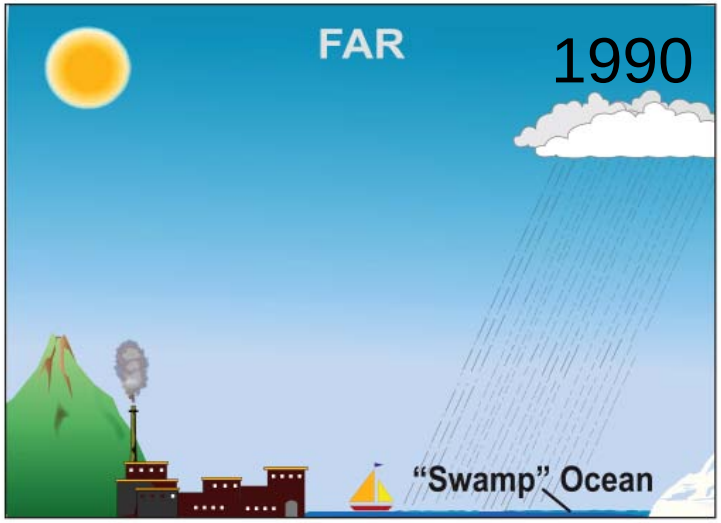


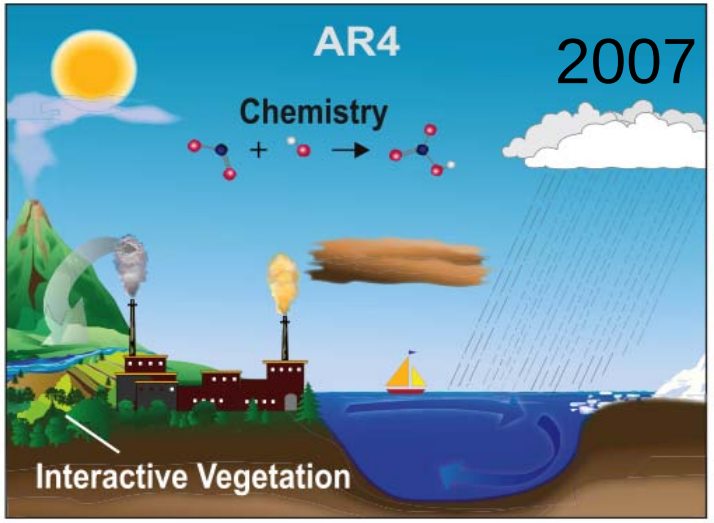
Three Topics

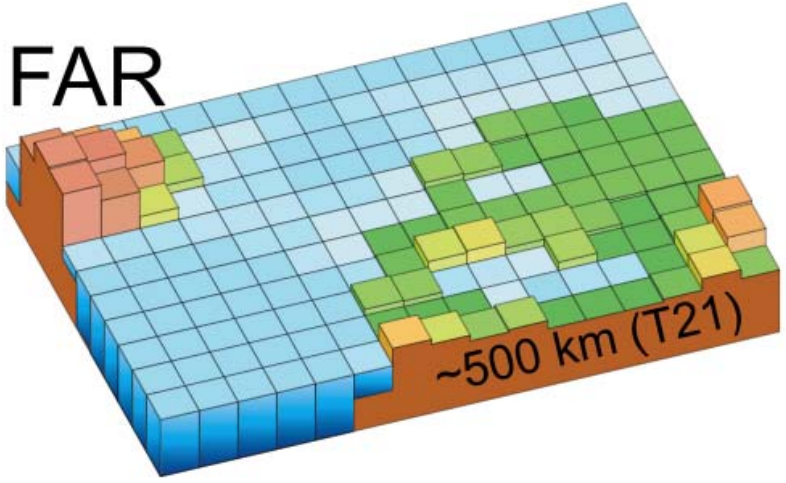
- Validity and selection of IPCC Climate models for the North Pacific (mostly done)
- Revisit Climate Projections on Seasonal/yearly (persistence), Decadal (regimes), as well as Multi-decadal (global warming) timescales
- Statistical and Dynamical Downscaling apply to all time scales

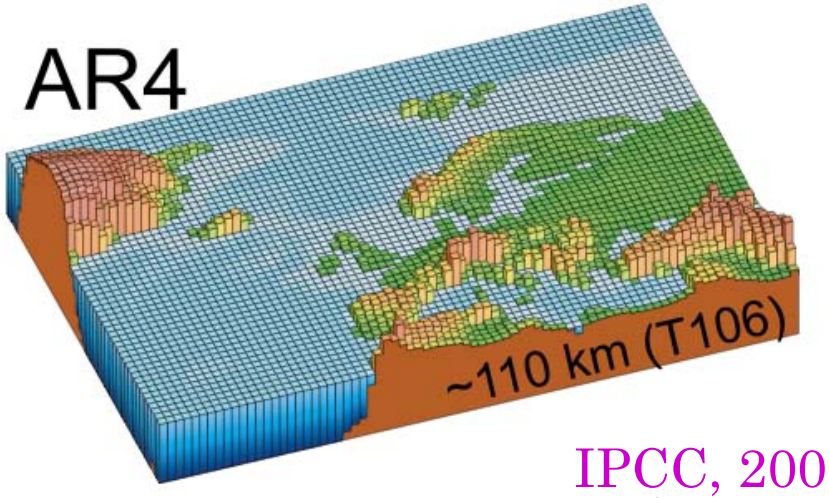
CCCC, CFAME, WG20----FUTURE

The Progress of Climate Models



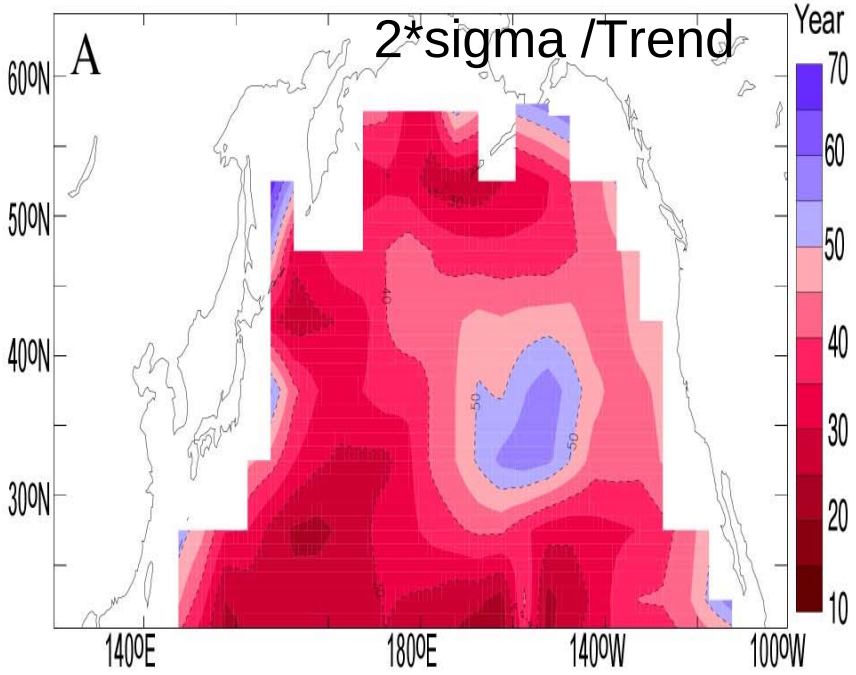






IPCC, 2007

Estimate of year when trend passes the magnitude of natural variability



Overland and Wang, 2007

Conclusion

IPCC models have utility but can vary in their ability to hindcast climate patterns base on location, variable of interest, and analysis methods (e.g. means, variance, trends, etc).

The question of model reliability has no simple quantitative answer; there is no one best model (Gleckler et al. 2008). Application Dependent.

How many climate models are needed?

- **Ensembles:** running the same model many times with different starting conditions- **represents range of natural variability**

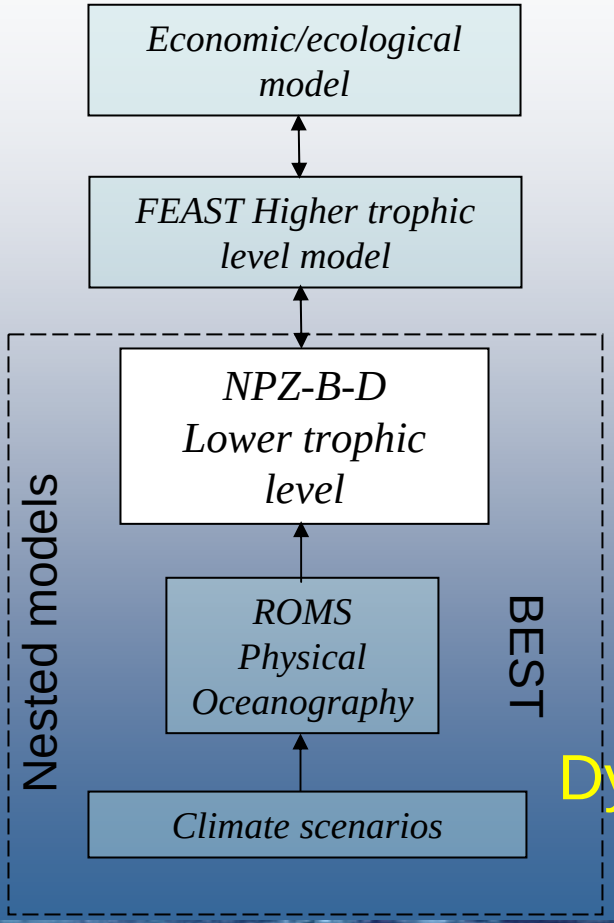
- **Model to model differences-** Rough estimate of parameterization (physics) and structural (other model development) uncertainly

Common practices to assess models' performance (Observational Constraint) are:

- Mean climate
- Variance
- Seasonal cycle
- Correlation (No)
- Trends (Not so good)

Region	Parameter	Purpose
Beaufort Sea	Summer Sea Ice	Polar Bears
Bering Shelf	Spring Winds	Flatfish
Bering Shelf	Summer SST	Lower - trophic Levels
Bering Shelf	Winter/Spring Sea Ice	Seal Pollock Whales
West Alaska	Spring SAT	Chum Salmon
Unimak Pass	Winter - Spring Winds	Chum Salmon
Shelikof Strait	Spring Winds SST	Pollock
Kodiak Isl and	Winter - Spring Precip	Pollock
East China Sea	Winter - Spring Winds	Mackerel
NW Hawaii	Summer SST	Coral Reef Health
Oregon Coast	Summer Upwelling	Lower - trophic Levels
Morocco Coast	Summer Upwellin g	Lower - trophic Levels
Peru Coast	Summer Upwelling	Lower - trophic Levels
NE Pacific	Zonal Wind s	Zooplankton
Barents Sea	Bott o m Te mp	Cod
North Sea	Bott o m Te mp	Cod
Arctic Land	SAT	Variability Mech anisms
N Pacif ic	SST	Past & Future Changes
Kuroshio	Winds	IPCC m o del tests
Gulf Stream	Winds	IPCC m o del tests
Pacific NW	SST/ SAT/ T850	Future Trends
Japan Sea	SST	Future Trends

BSIERP Integrated modeling



Dynamical Downscaling

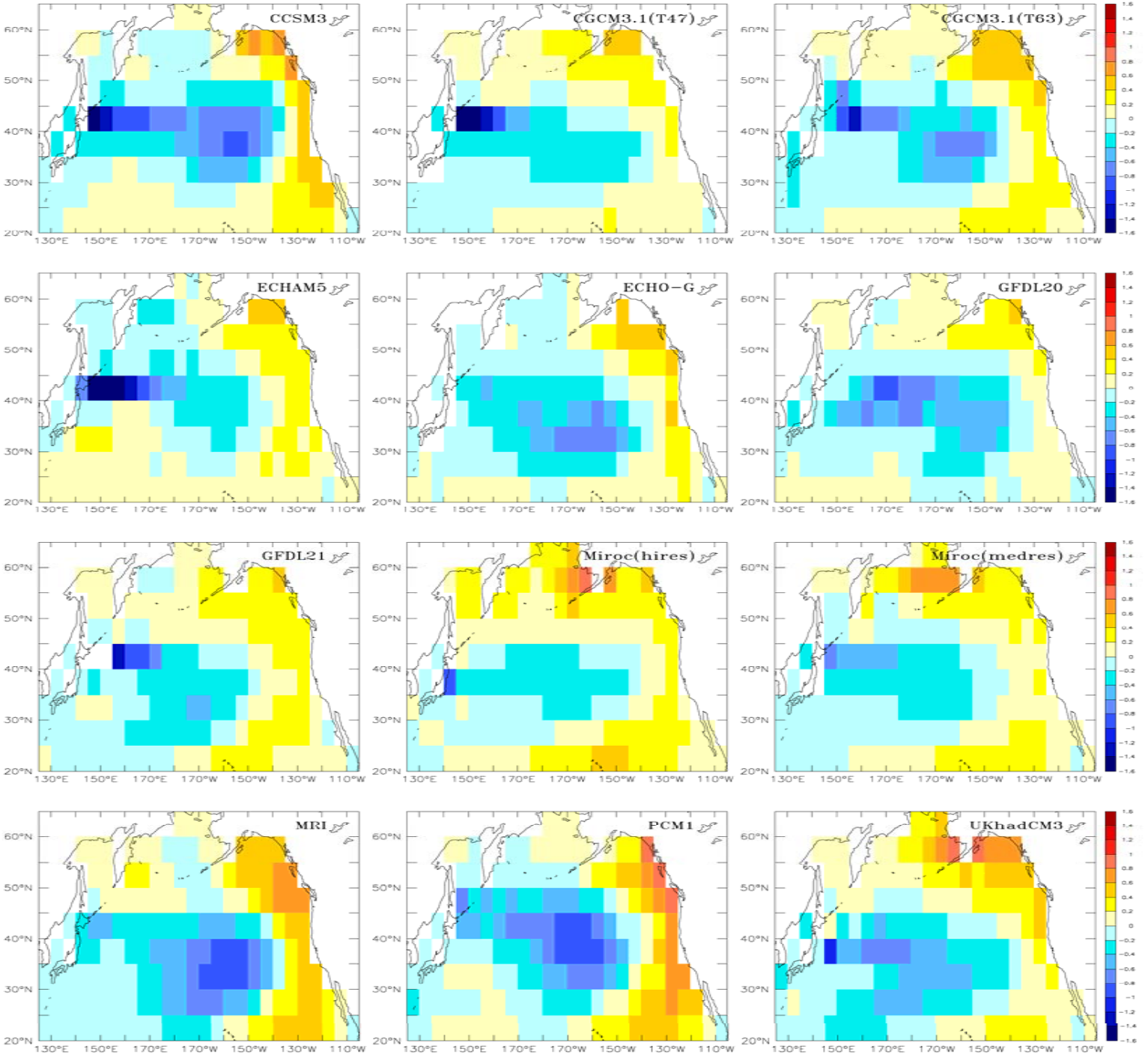
PMEL Method for using IPCC model simulations to project changes in Climate for Marine Ecosystems of the North Pacific

1. Initial Selection - Pick models that replicate the observed "Largescale Climate" character of the PDO in their 20th century hindcasts (12 of 22 pass test)
2. Regional Perspective – Determine "Observational Constraints" Examine specific parameter(s) in region of interest and metrics: means, variances, seasonality, etc.
3. Model projections – Select models and weighting
4. Uncertainty/Confidence - Estimate based on a combination of inter-model and intra-model variances in projections

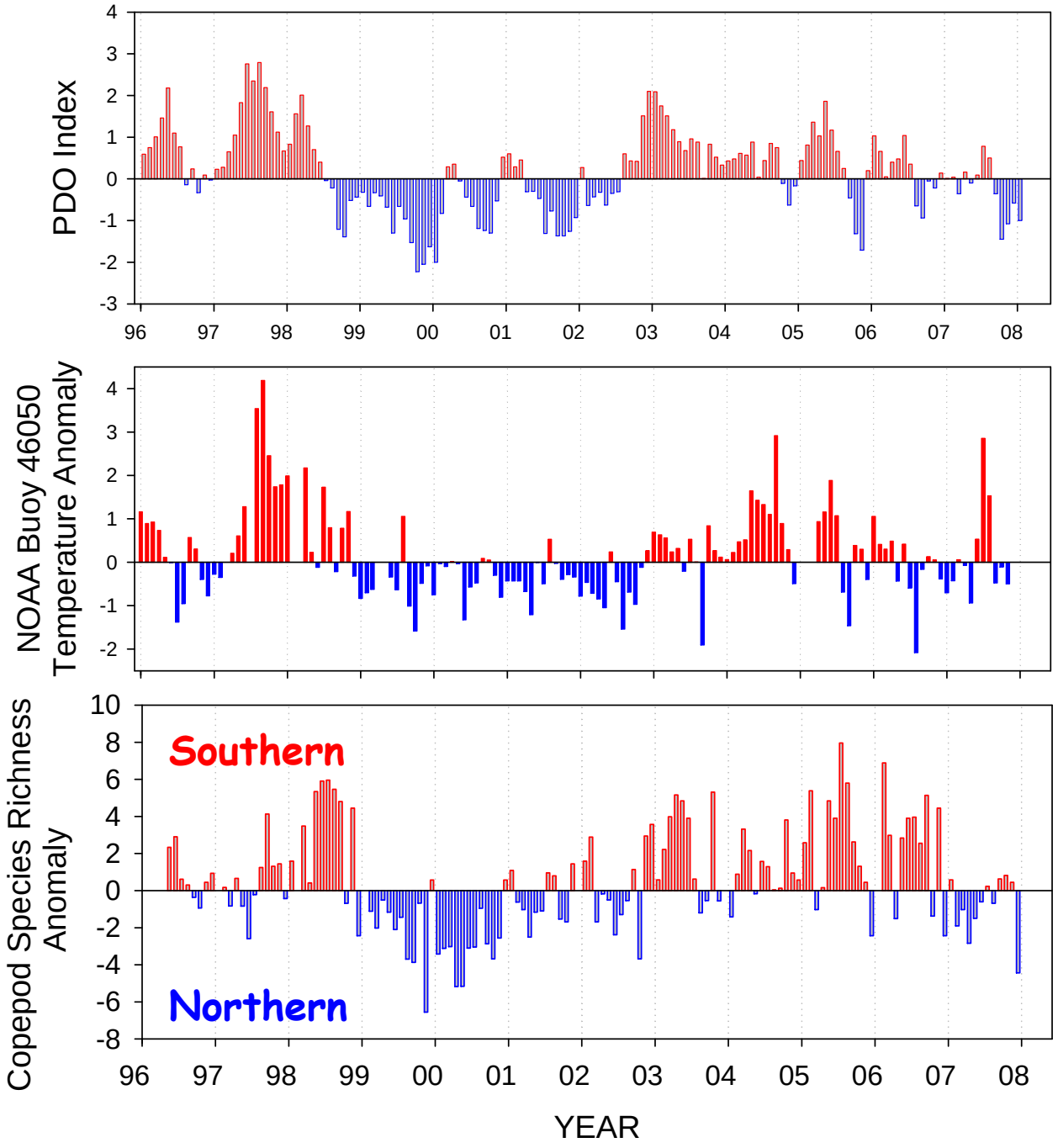
EOF1 of SST: Pacific Decadal Oscillation

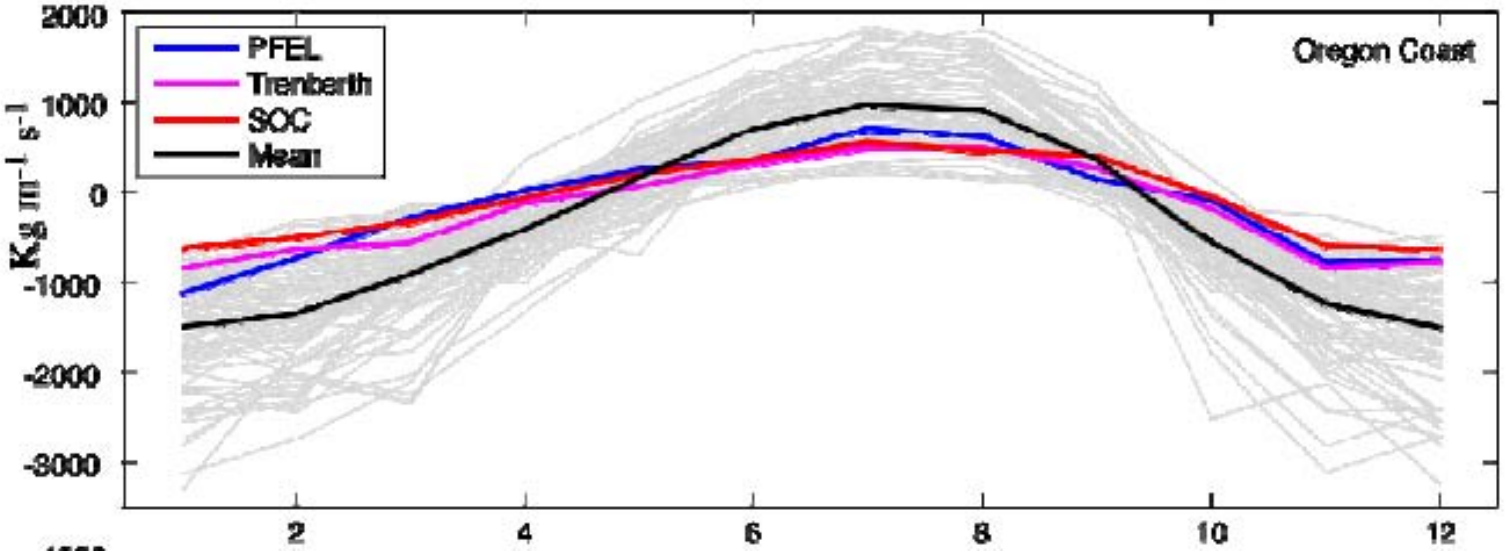
20th Century

12 of 23 models selected



PDO, SST, Upwelling and NE Pacific Copepods



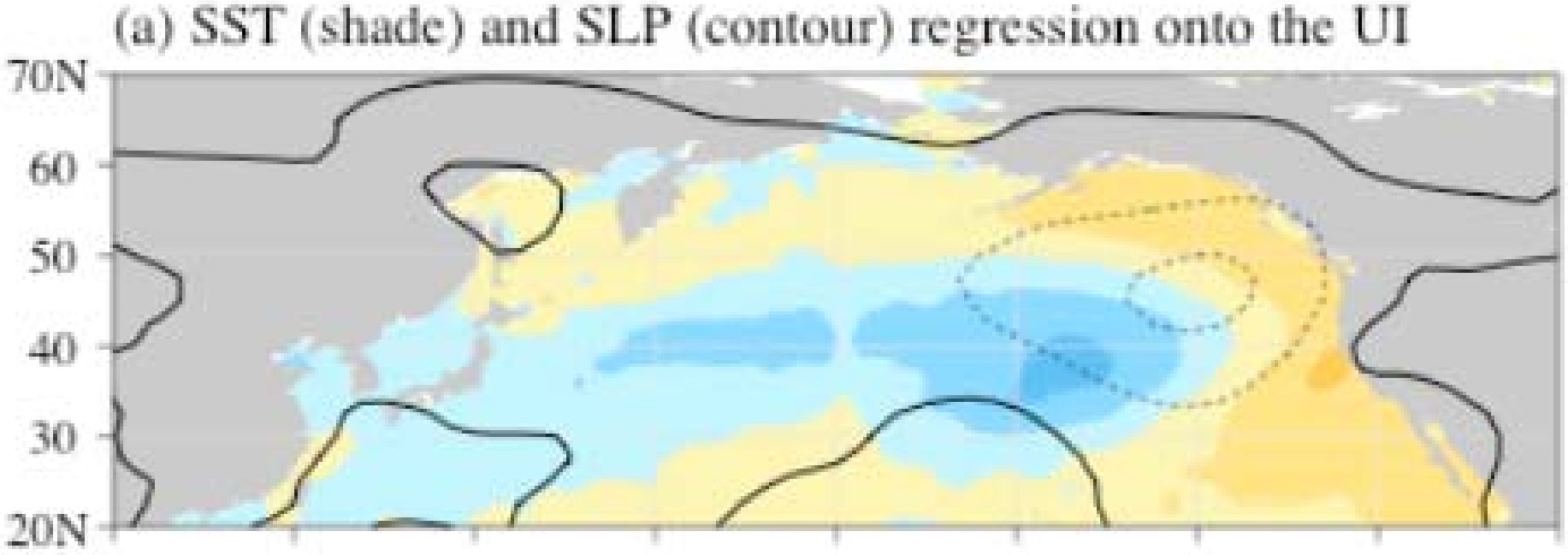


Upwelling

IPCC Winds (grey) are Too Strong

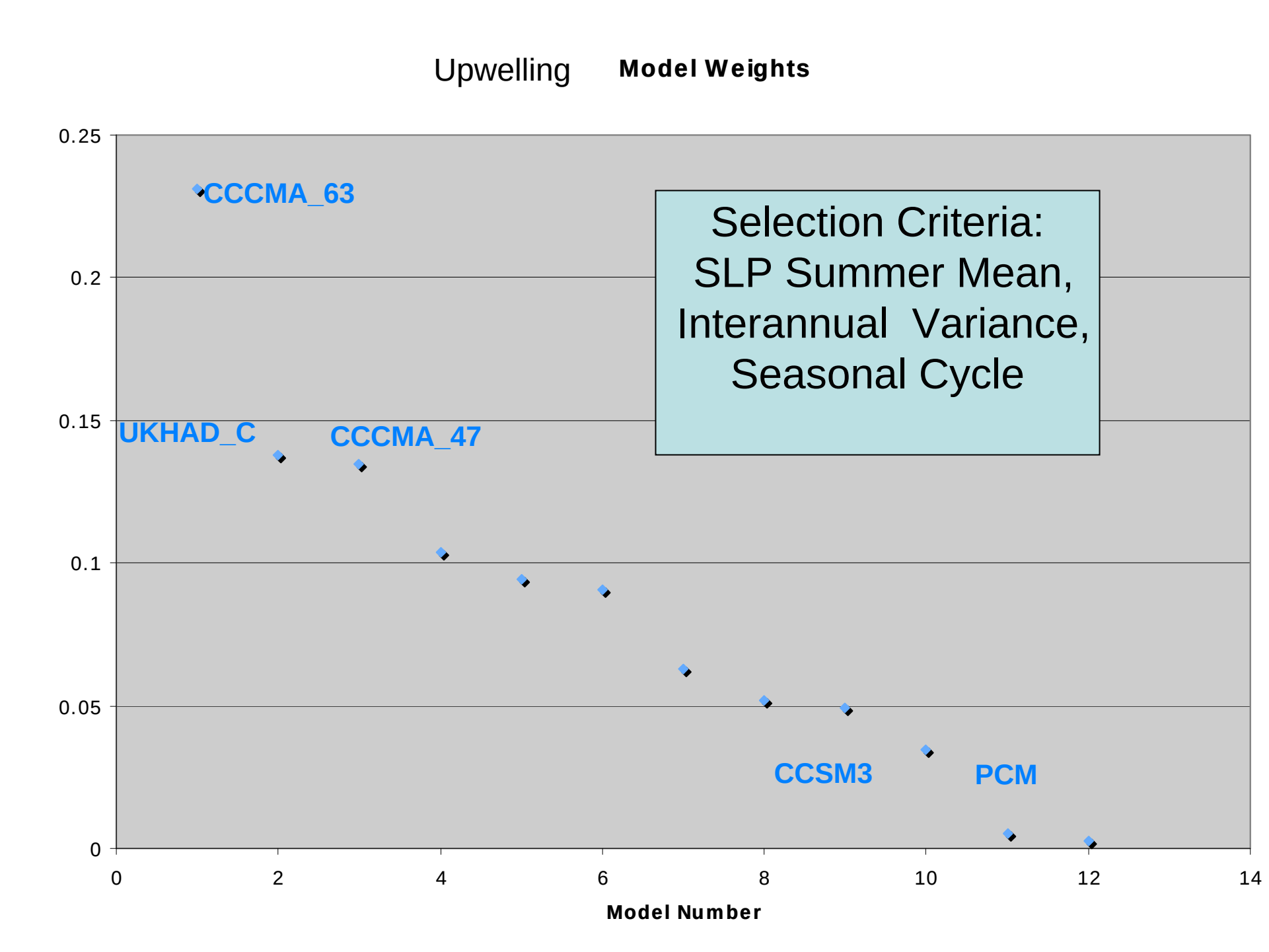
Cannot use directly

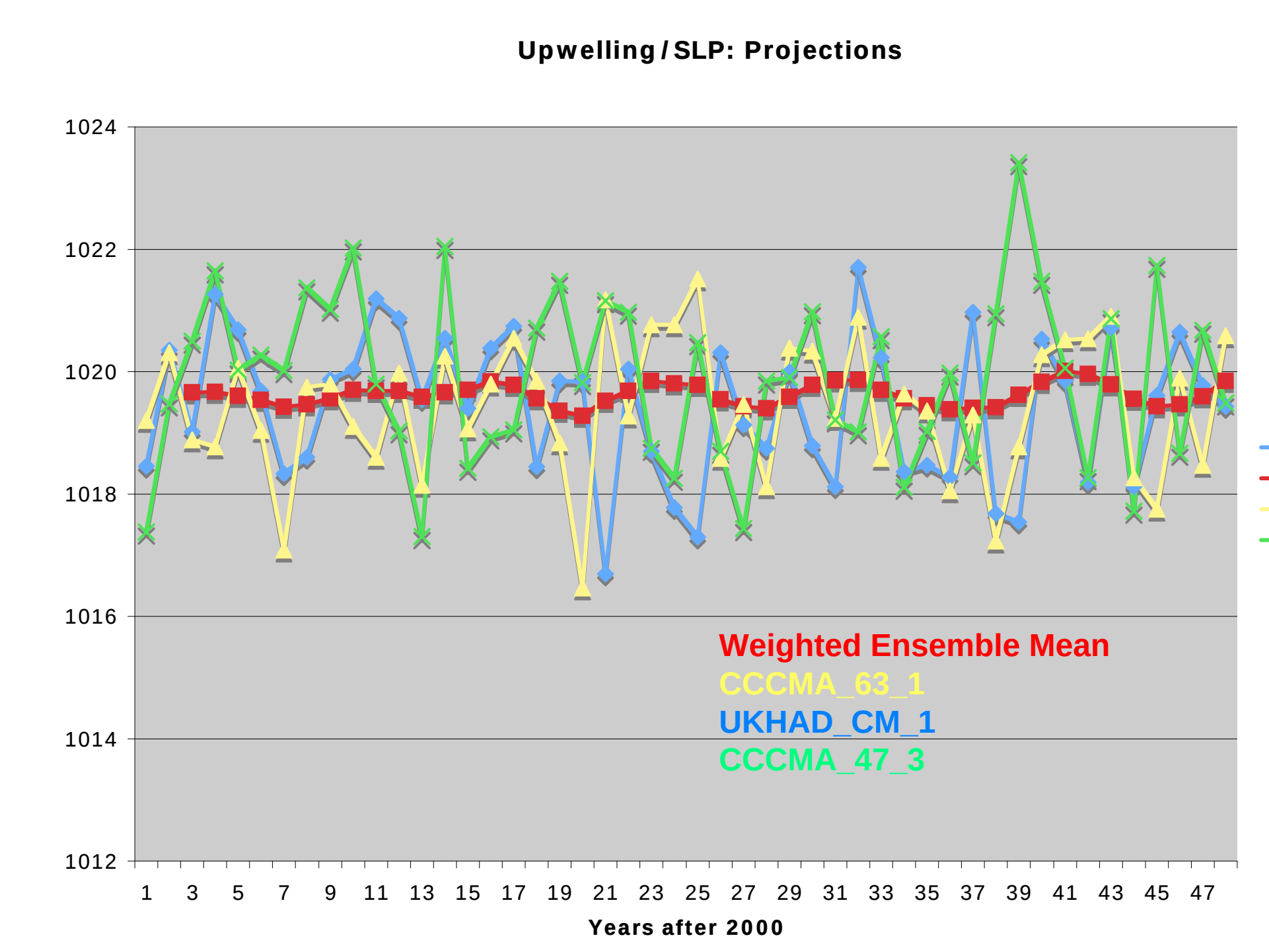
Try Downscaling

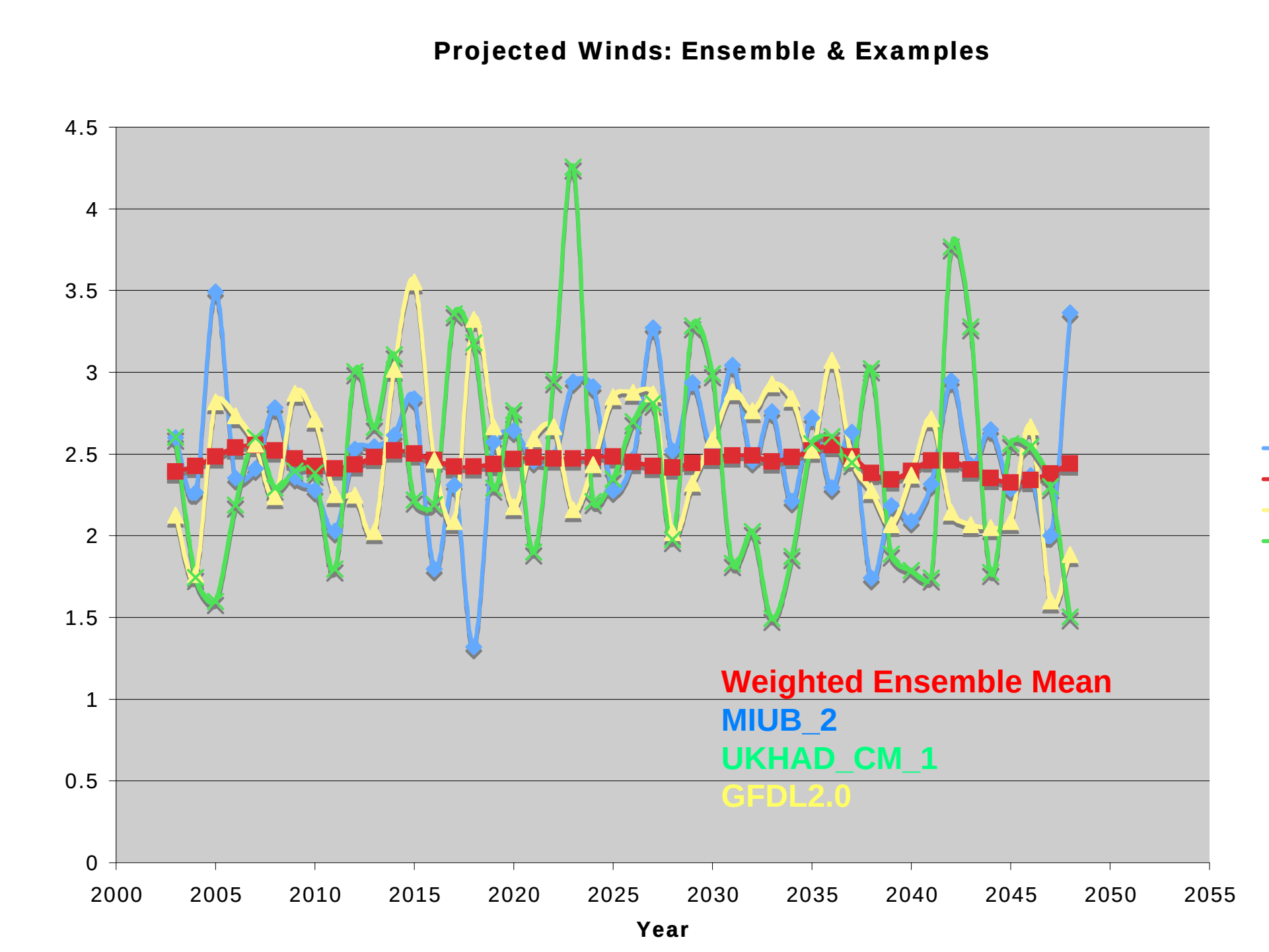


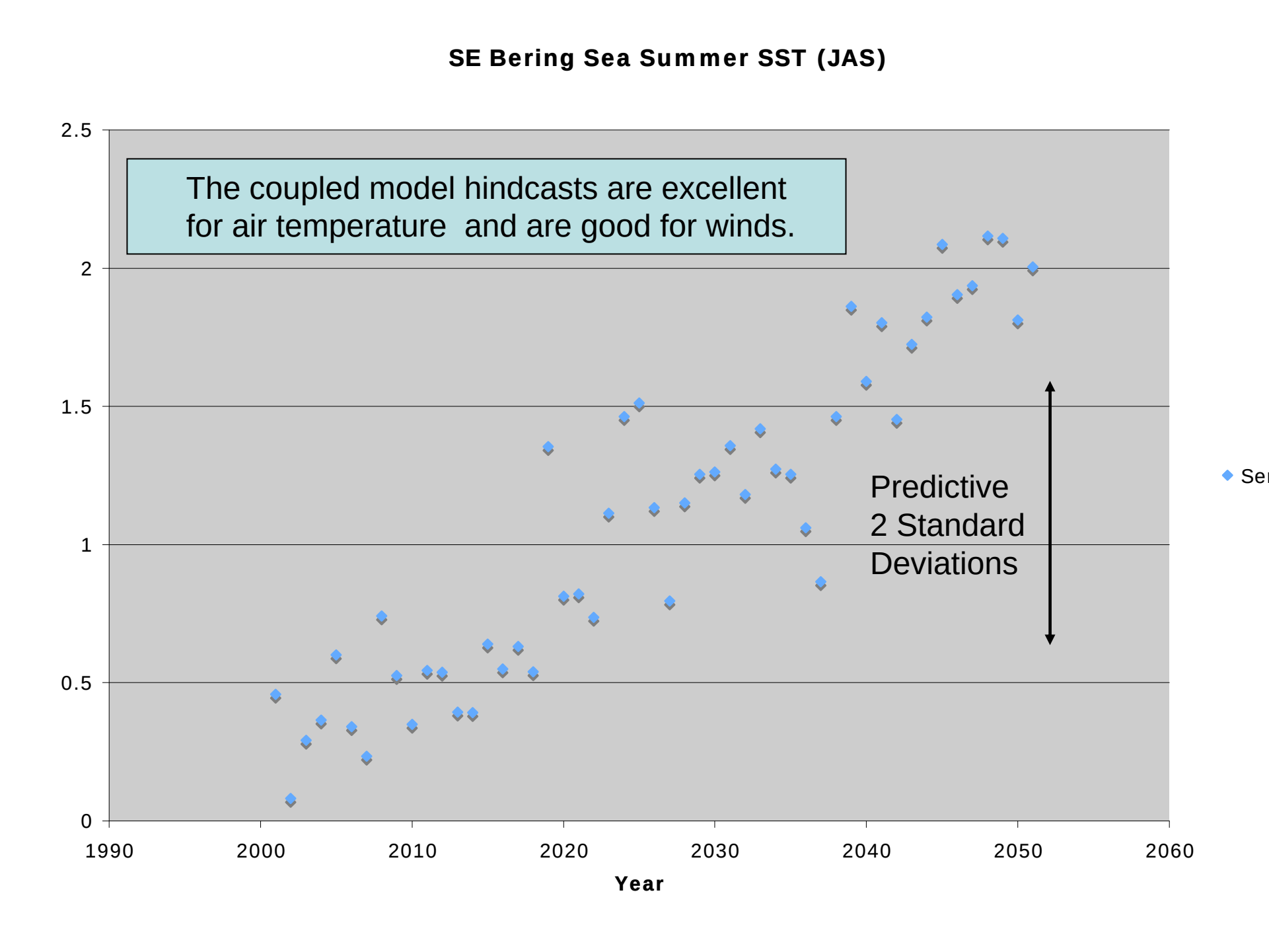
Schwing et al. 2006

Observed Upwelling Index (Local) versus large scale SLP Field

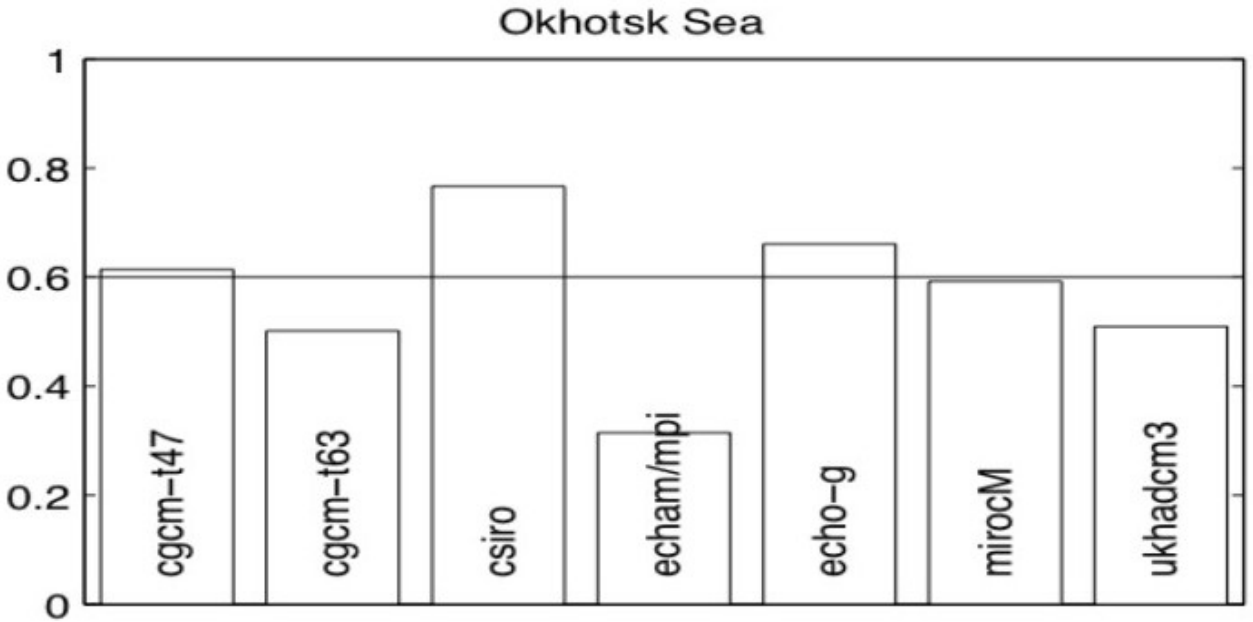

Upwelling
Model Weights
0.25
0.2
0.15
0.1
0.05
0
CCCMA_63
UKHAD_C
CCCMA_47
CCSM3
PCM
Selection Criteria:
SLP Summer Mean,
Interannual Variance,
Seasonal Cycle
0
2
4
6
8
10
12
14
Model Number

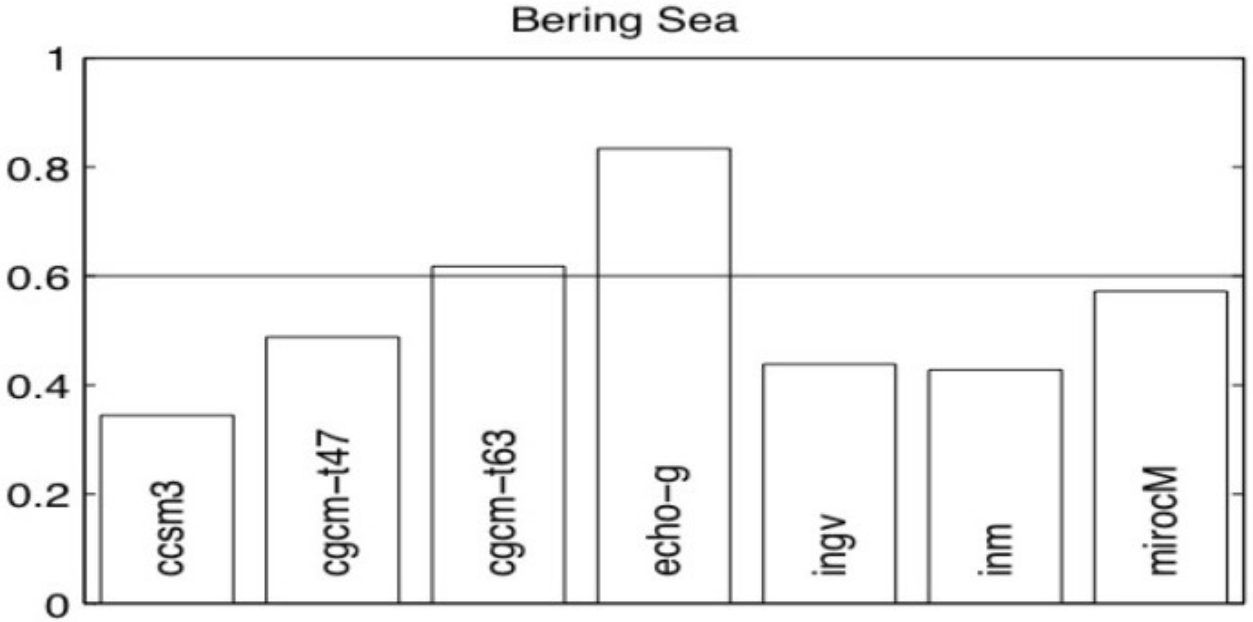

Upwelling / SLP: Projections
1024
1022
1020
1018
1016
1014
1012
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47
Years after 2000
Weighted Ensemble Mean
CCCMA_63_1
UKHAD_CM_1
CCCMA_47_3

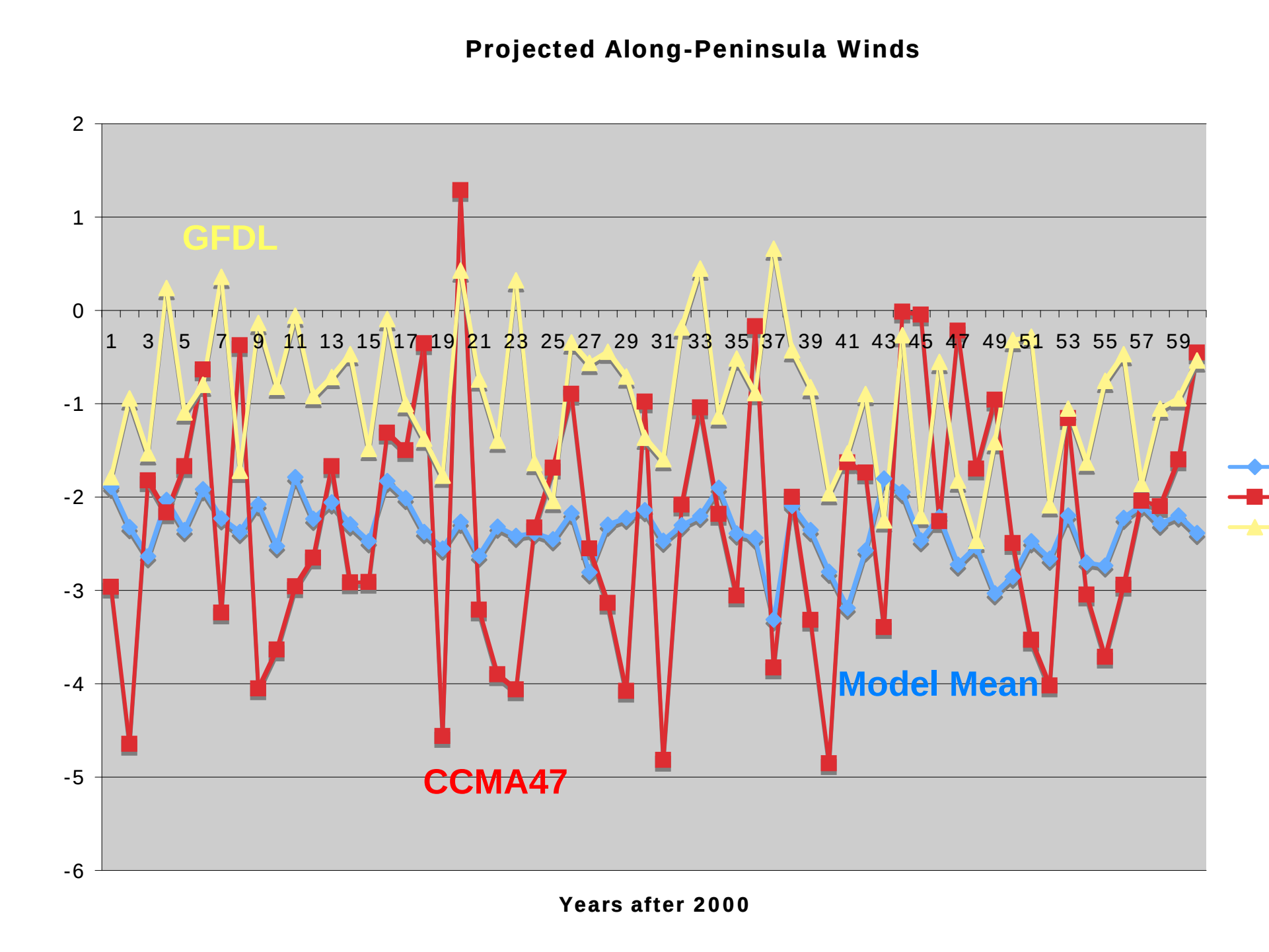

Projected Winds: Ensemble & Examples
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
2000
2005
2010
2015
2020
2025
2030
2035
2040
2045
2050
2055
Year
Weighted Ensemble Mean
MIUB_2
UKHAD_CM_1
GFDL2.0


SE Bering Sea Summer SST (JAS)
The coupled model hindcasts are excellent for air temperature and are good for winds.
Predictive 2 Standard Deviations
2.5
2
1.5
1
0.5
0
1990
2000
2010
2020
2030
2040
2050
2060
Year

Fraction Winter Ice Area 2050






Projected Along-Peninsula Winds
2
1
0
-1
-2
-3
-4
-5
-6
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47 49 51 53 55 57 59
GFDL
CCMA47
Model Mean
Years after 2000

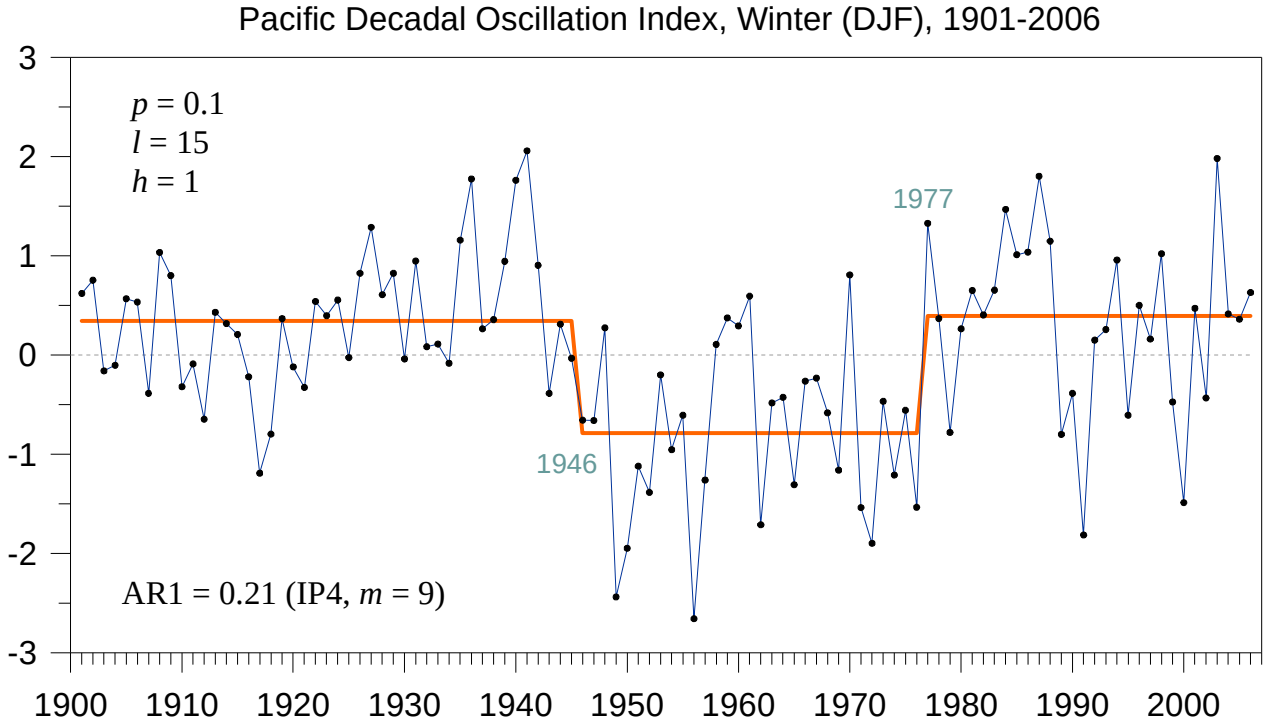
Meta-Analysis

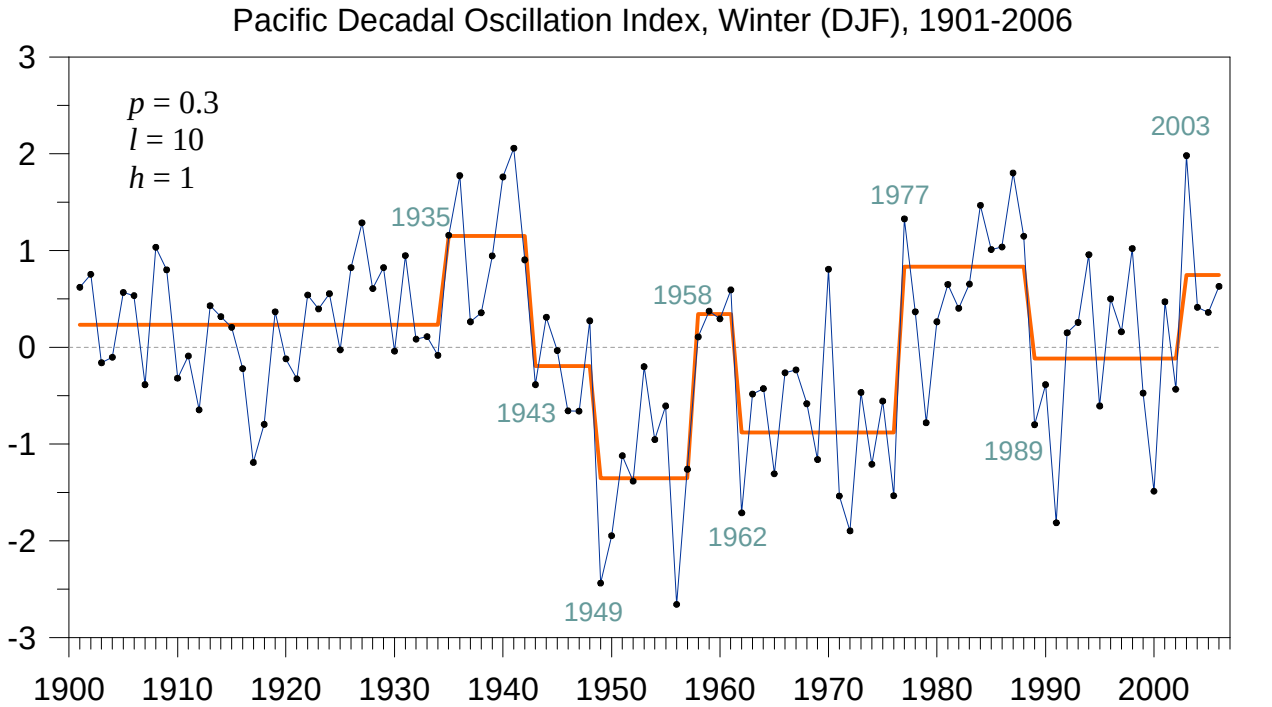
	Model ID	Country	Walsh et al. 2008				Overland & Wang 2007	Overland & Wang 2008	Gleckler et al., 2008			Reichler & Kim 2008
			NH SAT SSN Cycle with bias	SAT Bias removed	NH SLP with bias	SLP Bias removed	PDO	NH Summer Sea Ice	T850 20-90N	SLP	Overall	14- var Glb mean clim
1	BCCR-BCM2.0	Norway					fail	fail	red	14		16
2	CCSM3	USA	2	2	13	13	Pass	pass	blue		9	7
3	CGCM3.1(T47)	Canada	10	10	4	5	Pass	fail	blue	5	6	5
4	CGCM3.1 (T63)	Canada					Pass	fail	blue	4	8	9
5	CNRM-CM3	France	5	6	11	3	Pass	pass	blue	7	13	14
6	CSIRO-Mk3.0	Australia	12	13	9	10	fail	fail	red	19	7	13
7	ECHAM5/ MPI	Germany	1	1	1	1	Pass	fail	blue	1	2	3
8	ECHO-G (MIUB)	Germany/Korea					Pass	pass		3		
9	FGOALS-g1.0	China	15	15	10	9	fail		red	16	20	20
10	GFDL-CM2.0	USA	14	4	4	4	Pass	fail	red	9	11	10
11	GFDL-CM2.1	USA	5	3	2	2	Pass	fail	red	2	4	1
12	GISS-AOM	USA					fail	fail	blue	13	17	19
13	GISS-EH	USA					fail		red	18	15	22
14	GISS-ER	USA	10	12	14	14	fail	fail	red	20	18	18
15	Ingv	Italy						fail				11
16	INM-CM3.0	Russia	10	11	9	11	fail	fail	red	12	14	15
17	IPSL-CM4	France	12	8	15	15	fail	pass	red	21	19	17
18	MIROC3.2 (hires)	Japan					pass	fail	blue	11	5	8
19	MIROC3.2 (medres)	Japan	3	5	5	6	pass	pass	blue	8	10	12
20	MRI-CGCM2.3.2	Japan	7	7	6	7	pass	fail	red	15	12	4
21	PCM	USA	14	14	12	12	Pass	fail	red	17	16	21
22	UKMO-HadCM3	UK	6	10	6	7	Pass	fail	blue	10	3	6
23	UKMO-HadGem1	UK						pass	blue	6	1	2
24	BCC-CM1	China										
25	CSIRO-MK3.5	Australia										

Regimes and Multi-year Persistence

Statistically significant shifts in means relative to within-regime variance

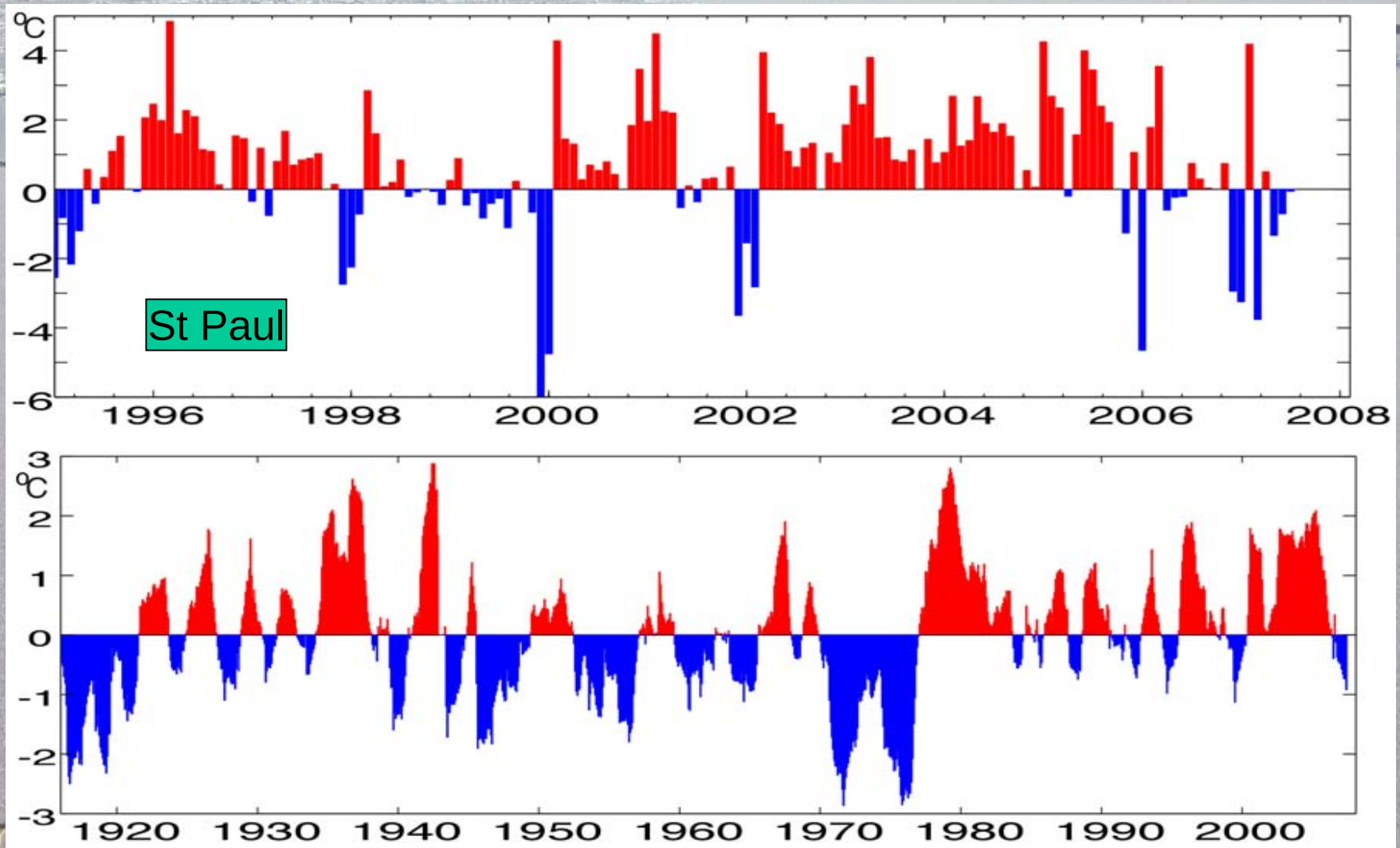
(Overland et al. 2008)





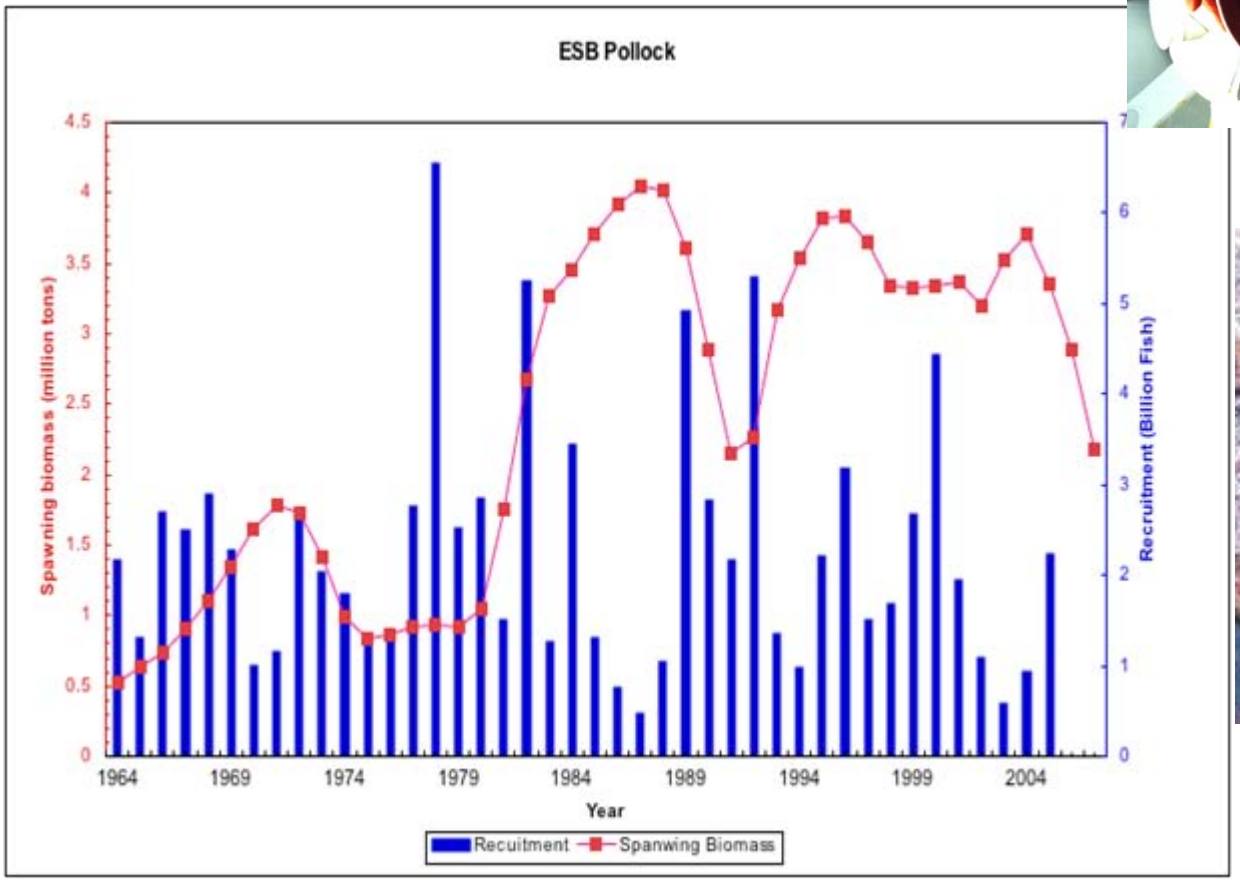
Mean monthly surface air temperatures anomalies in St. Paul, Pribilof Islands

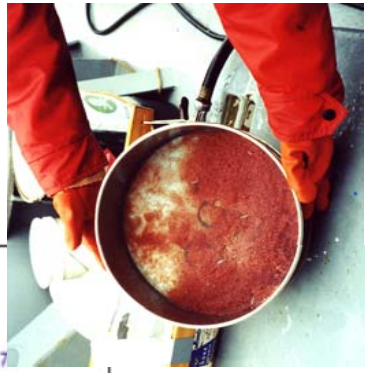
Needs more work on multi-year persistence and stochastic behavior for Decadal Scale Forcing of Ecosystems



Southern Bering Sea Ecosystem Reorganization

Warm temperatures favored pollock over Arctic species. But recently poor food, more predators, and cold temperatures gives a biomass loss of 30%





2000

2001

Summary

Use Dynamical and Statistical Downscaling

No One Best IPCC Model, Choose 3-10 models to sample structural variability

Model Selection: Remove Outliers--Use Observational Constraints--should be good on large scale climate as well as regionally

Characterize Multi-year as well as Global Warming timescales

PICES **FUTURE**