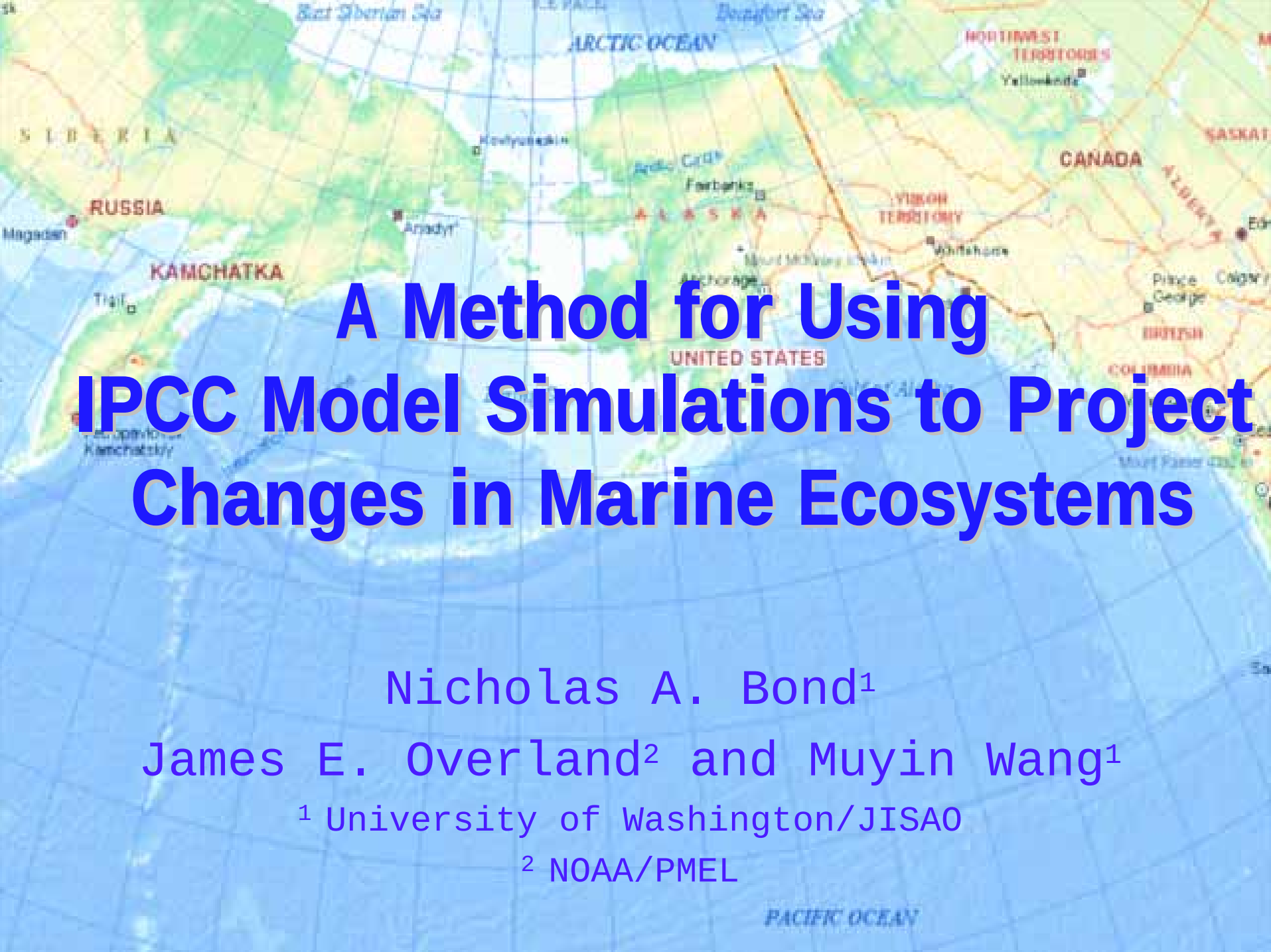

Positive proof of global warming.
18th Century
1900
1950
1970
1980
1990
2006



A Method for Using IPCC Model Simulations to Project Changes in Marine Ecosystems

Nicholas A. Bond[1]

James E. Overland[2] and Muyin Wang[1]

[1] University of Washington/JISAO

[2] NOAA/PMEL

Models Contributed to IPCC AR4

	IPCC I.D.	Country	Atmosphere Resolution	Ocean Resolution	# of Control runs	# of 20c3m runs	# of A1B runs
1	BCCR-BCM2.0	Norway	T63L31	(0.5-1.5°) x 1.5°L35	2	1	1
2	CCSM3	USA	T85L26	(0.3-1.0°) x 1.0°L40		1	1
3	CGCM3.1(T47)	Canada	T47L31	1.9° x 1.9°L29	2	5	5
4	CGCM3.1 (T63)	Canada	T63L31	1.4° x 0.9°L29	1	1	1
5	CNRM-CM3	France	T42L45	182x152L31	3	1*	1
6	CSIRO-Mk3.0	Australia	T63L18	1.875° x 0.925° L31	3	3	1
7	ECHAM5/ MPI-OM	Germany	T63L31	1.5°x1.5°L40			
8	FGOALS-g1.0 (IAP)	China	T42L26	1°x1°xL30	9	3	3
9	GFDL-CM2.0	USA	2.5°x2.0° L24	1°x1°L50	5	3	1
10	GFDL-CM2.1	USA	2.5°x2.0° L24	1°x1°L50	5	5	1
11	GISS-AOM	USA	T42L20	1.4°x1.4°L43	2	2	2
12	GISS-EH	USA	5°x4°L20	2°x2° *cos(lat) L16	4	5	3
13	GISS-ER	USA	5°x4°L13	5°x4°L33	1	9	5
14	INM-CM3.0	Russia	5°x5°L21	2°x2.5°L33	2	1	1
15	IPSL-CM4	France	3.75°x2.5° L19	2°x1°L31	3	1	1
16	MIROC3.2(hires)	Japan	T106 L56	0.28°x0.188° L47	1	1	1
17	MIROC3.2(medres)	Japan	T42 L20	(0.5°-1.4°)x1.4° L44	3	3	3
18	ECHO-G (MIUB)	Germany/Korea	T30L19	T42L20	1	3	3
19	MRI-CGCM2.3.2	Japan	T42 L30	(0.5°-2. 5°) x 2° L23	3	5	5
20	PCM	USA	T42L18	(0.5-0.7°) x 0.7° L32		1	
21	UKMO-HadCM3	UK	3.7°5x2.5° L15	1.25°x1.25° L20	2+1*	1	1
22	UKMO-HadGem1	UK	1.25°x1.875°L38	(0.33-1.0°) x 1.0° L40	1+2*	2	1*
	Sum					55	40

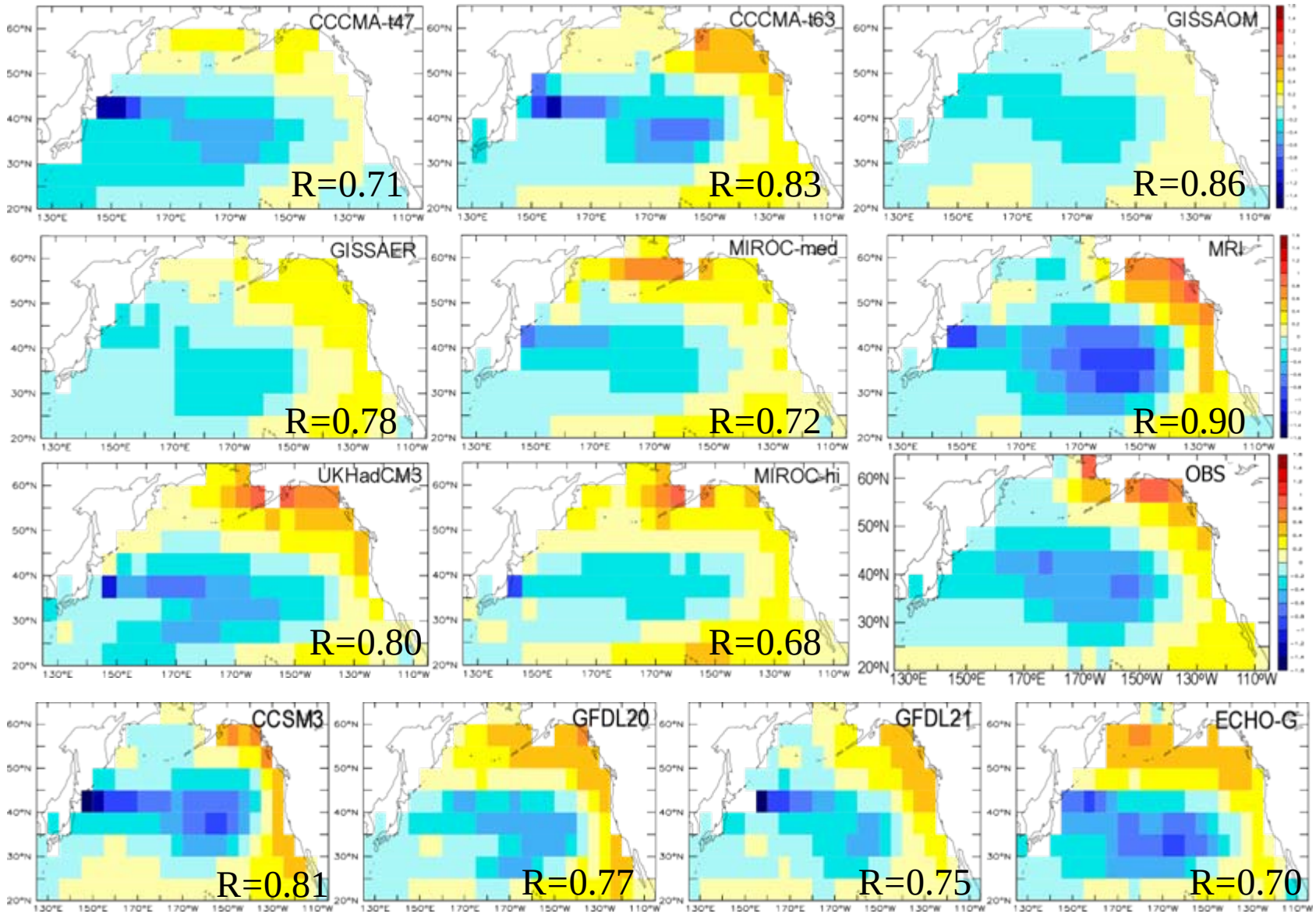
Bayesian Model Averaging (BMA)

- Considers an ensemble of plausible models
- Key Idea - There is a “best” model, but which one is uncertain
- Forecast PDF estimated through weighting the PDFs of the individual models, with weights determined by posterior model probabilities
- BMA possesses a range of properties optimal from a theoretical point of view; works well in short-term weather prediction

Procedure

- Retain IPCC models that replicate the PDO in their 20th century hindcasts
- Select parameter(s) and criteria (mean, variance, trend?) for the region/ecosystem of interest
- Compute errors (“distances”) between observations and hindcasts for the latter half of the 20th century
- Compute weights based on $W_i = \exp(-D_i/D_m)$
- Calculate PDFs of projections (ensemble weighted means and variances)

EOF1 of SST from 20C3M Simulations



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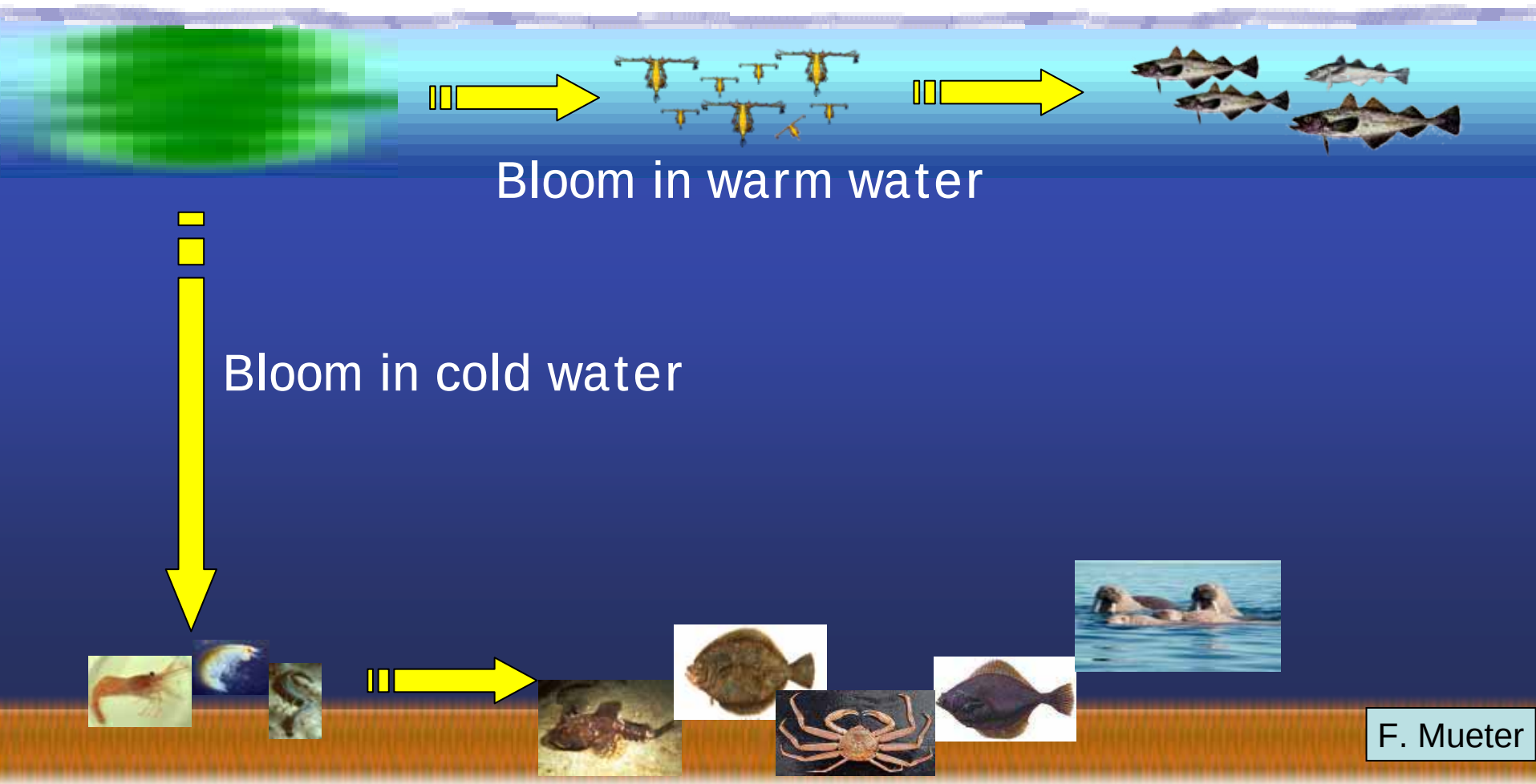
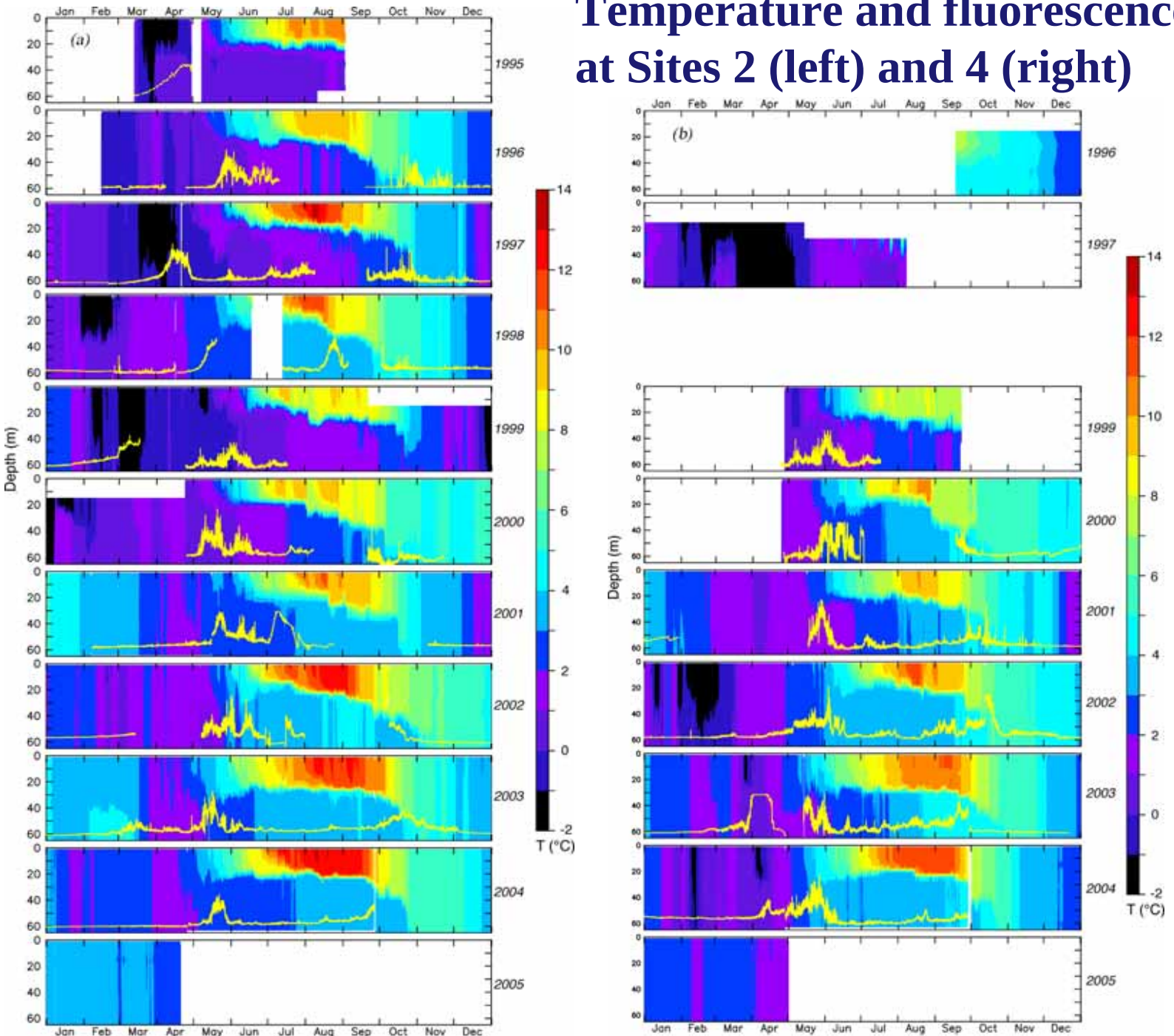
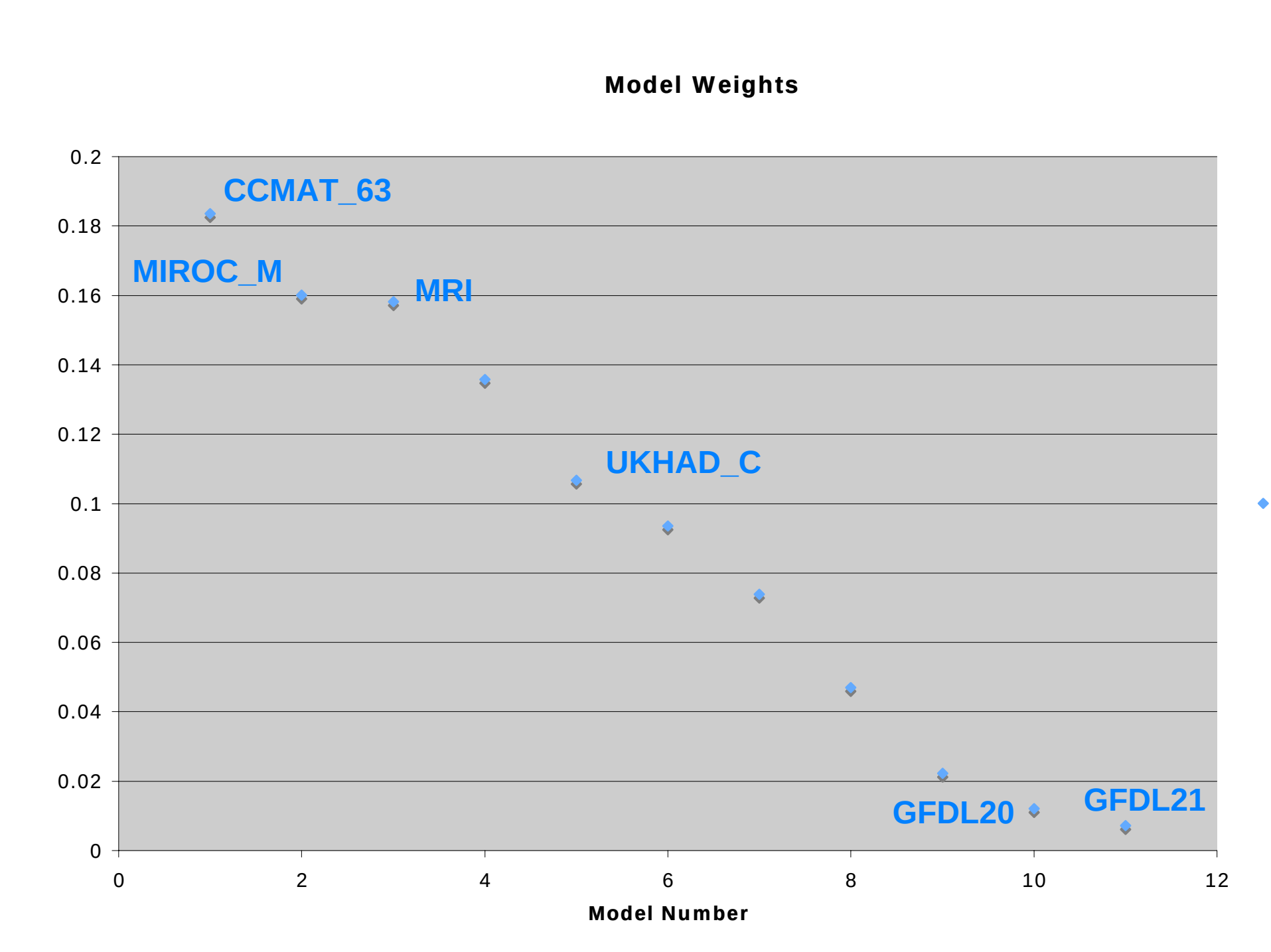
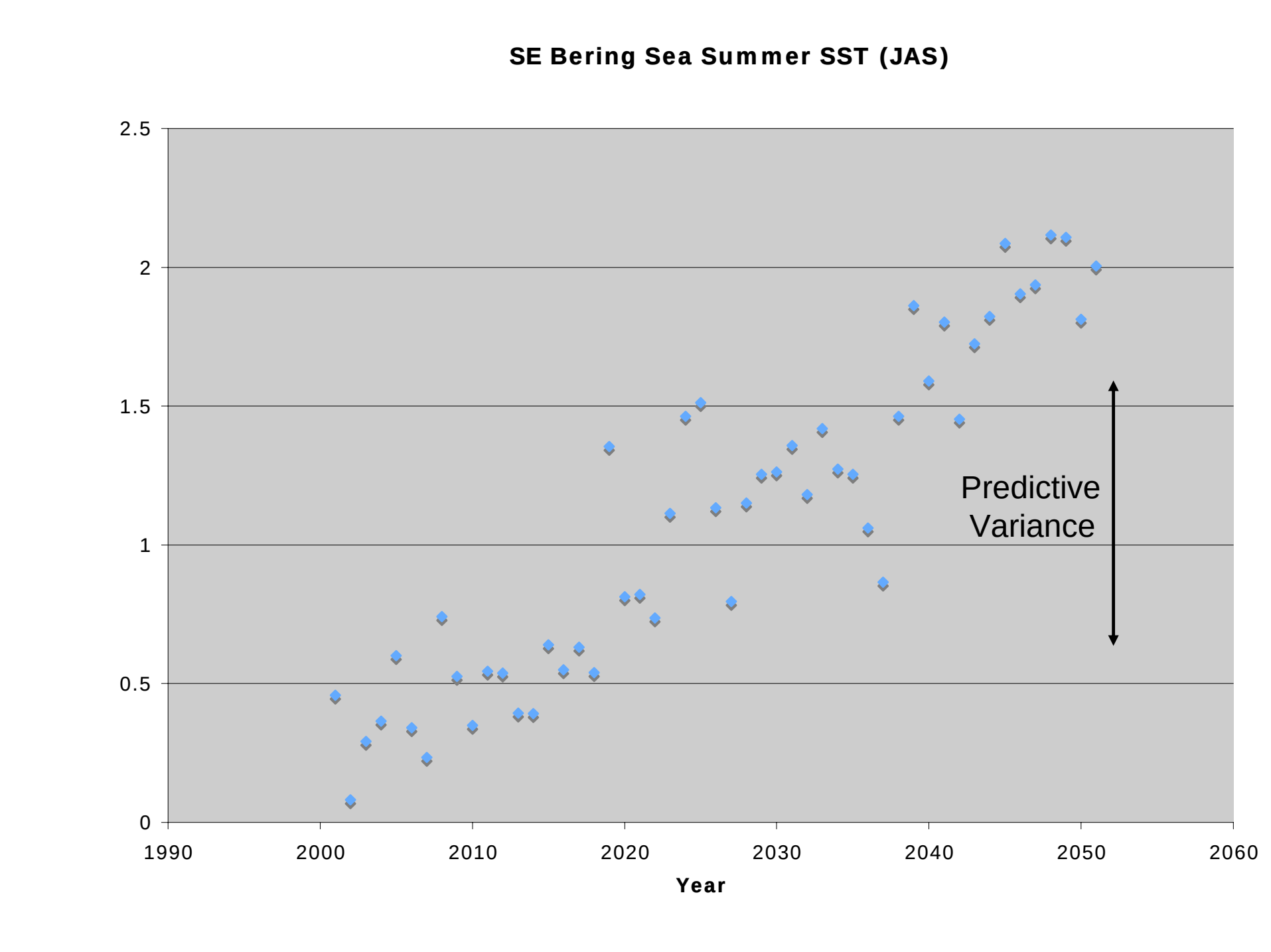
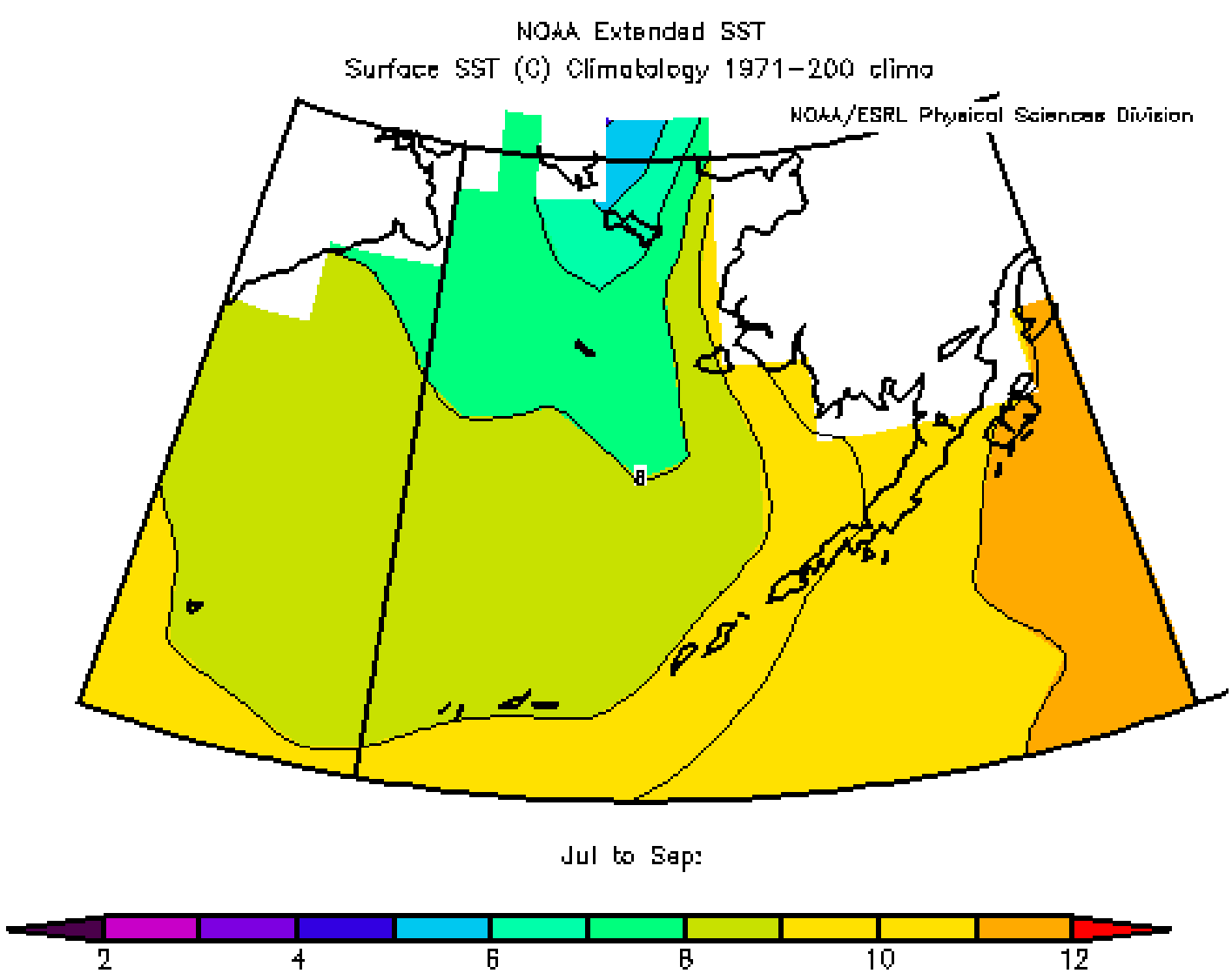

Bloom in warm water
Bloom in cold water
F. Mueter

Temperature and fluorescence at Sites 2 (left) and 4 (right)



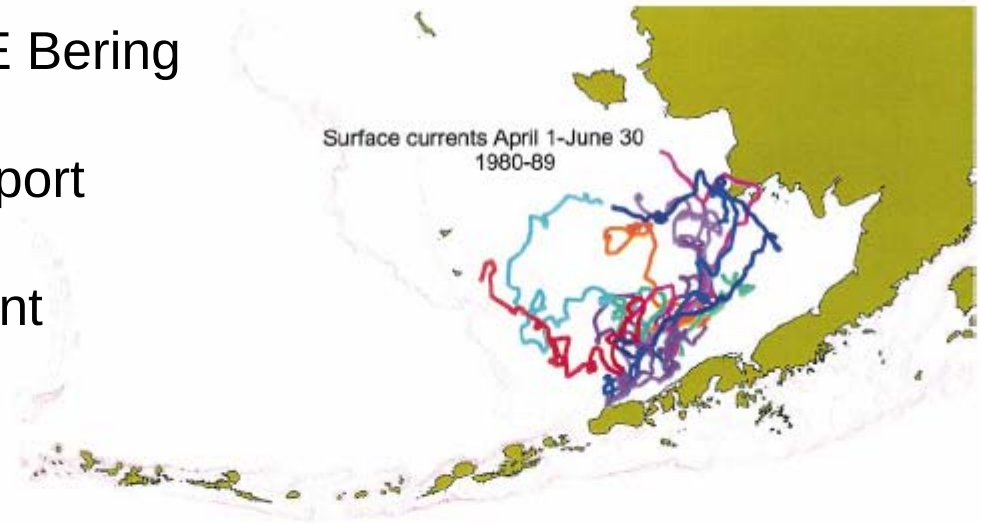

Model Weights
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
CCMAT_63
MIROC_M
MRI
UKHAD_C
GFDL20
GFDL21
0
2
4
6
8
10
12
Model Number

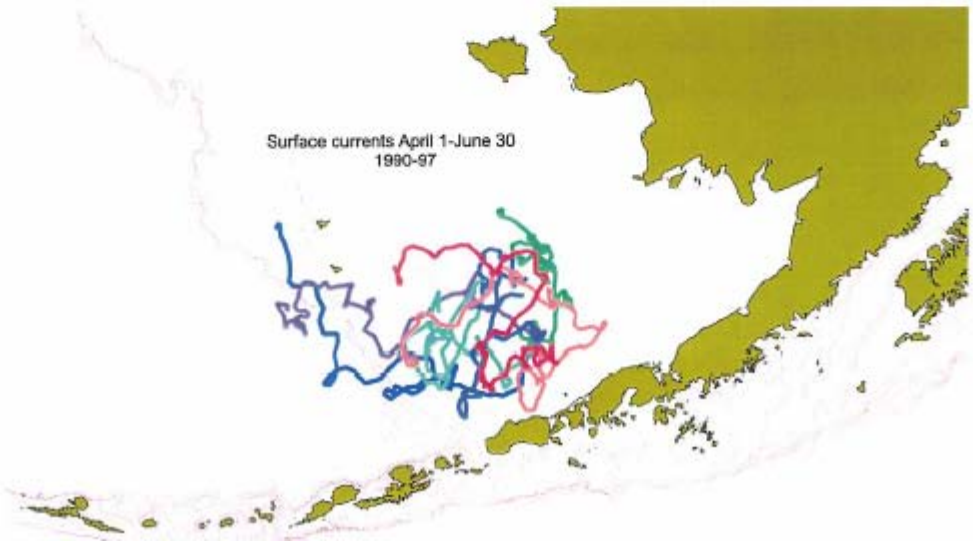

SE Bering Sea Summer SST (JAS)
2.5
2
1.5
1
0.5
0
1990
2000
2010
2020
2030
2040
2050
2060
Year
Predictive
Variance

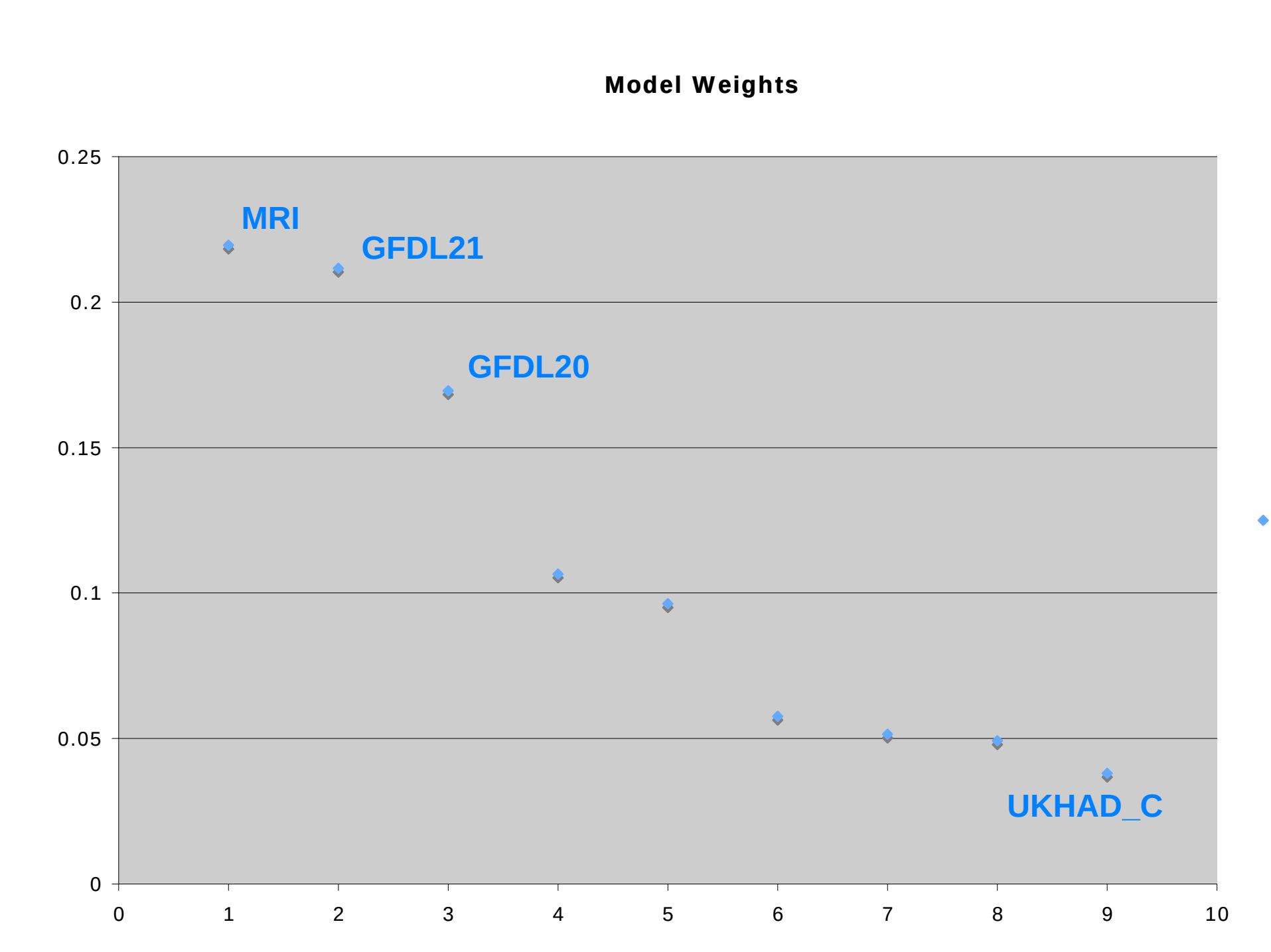

NOAA Extended SST
Surface SST (C) Climatology 1971-200 clima
NOAA/ESRL Physical Sciences Division
Jul to Sep:
2
4
6
8
10
12

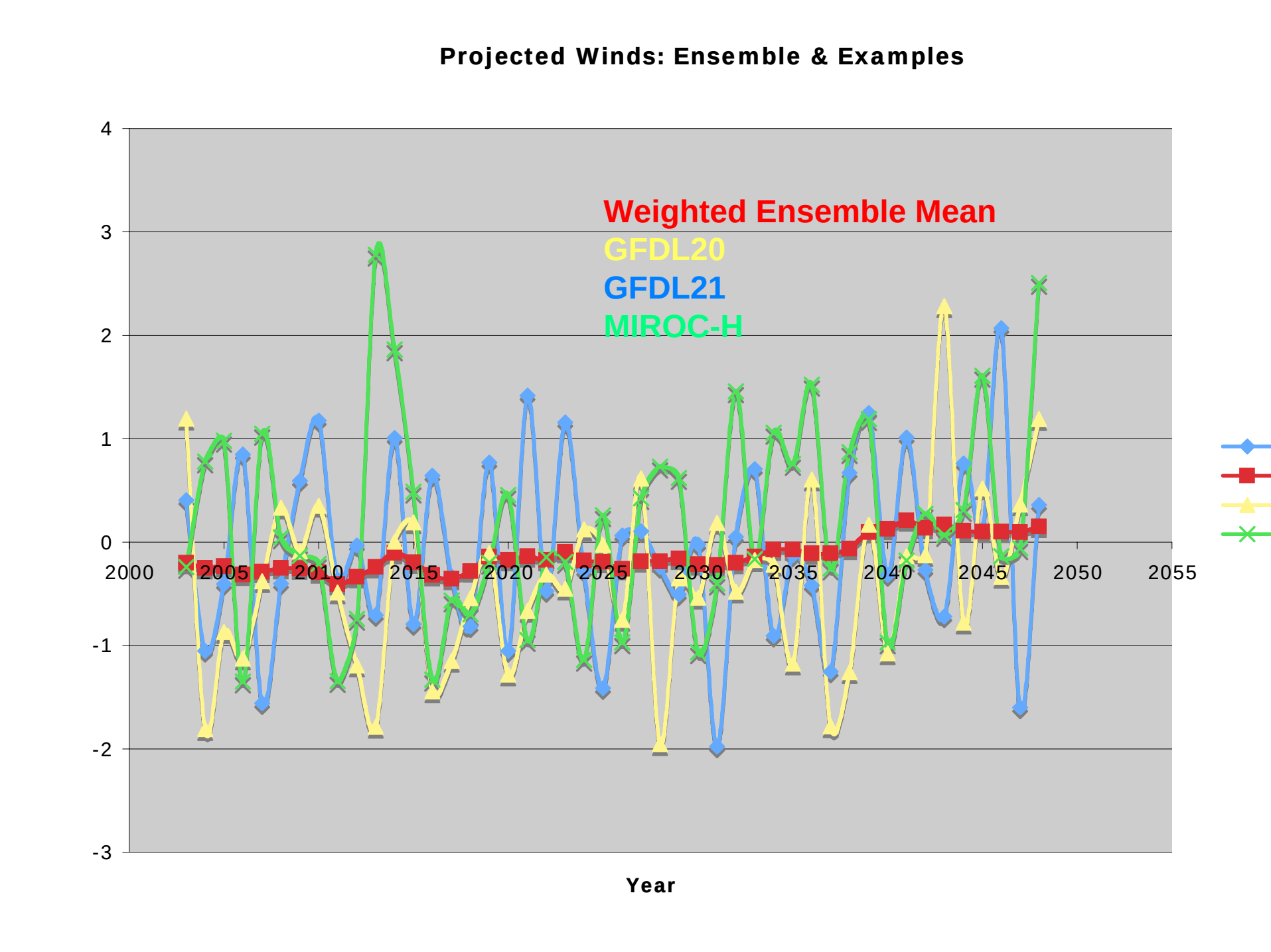
Flatfish in the SE Bering

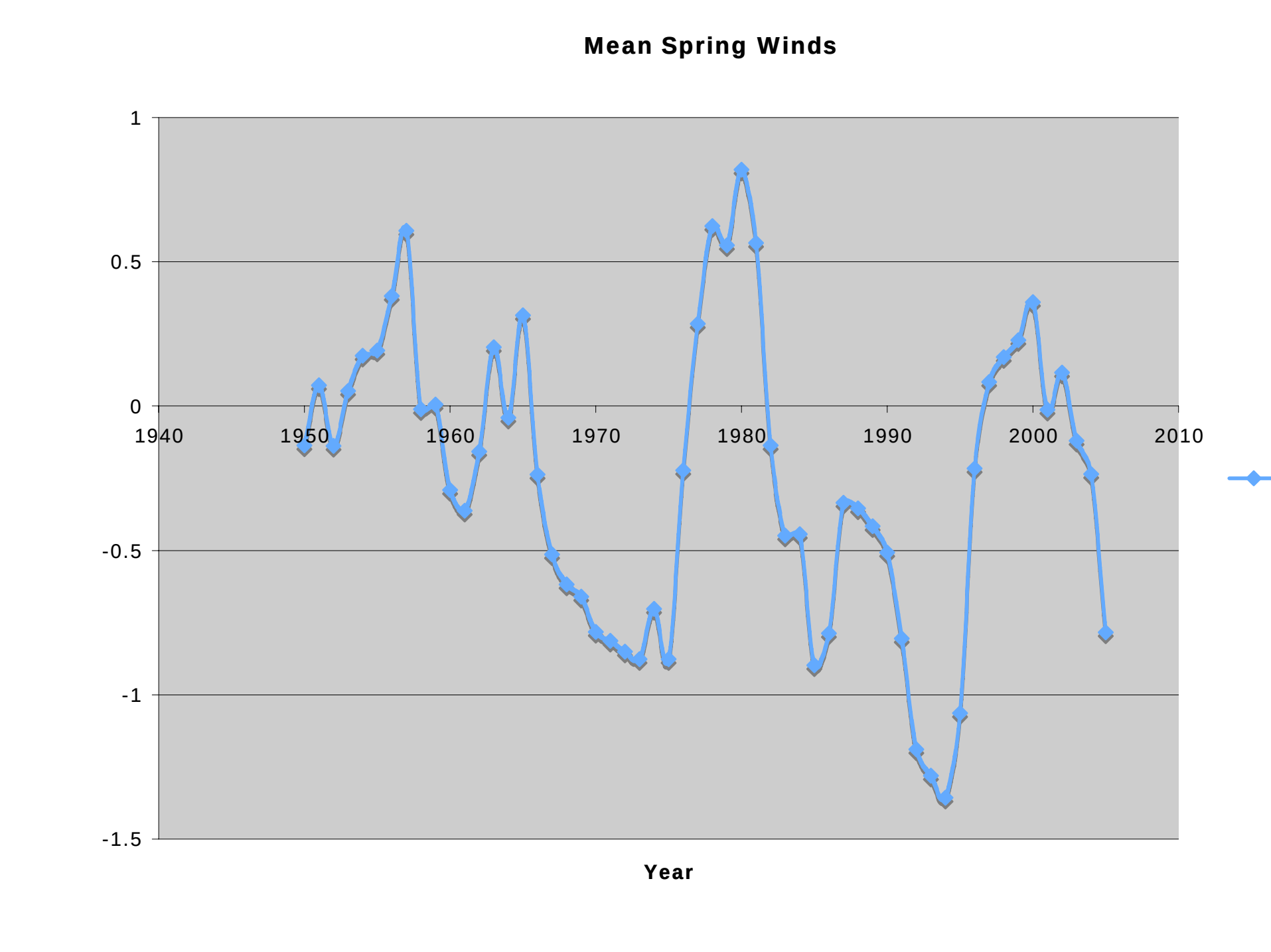
Larval Transport & Recruitment

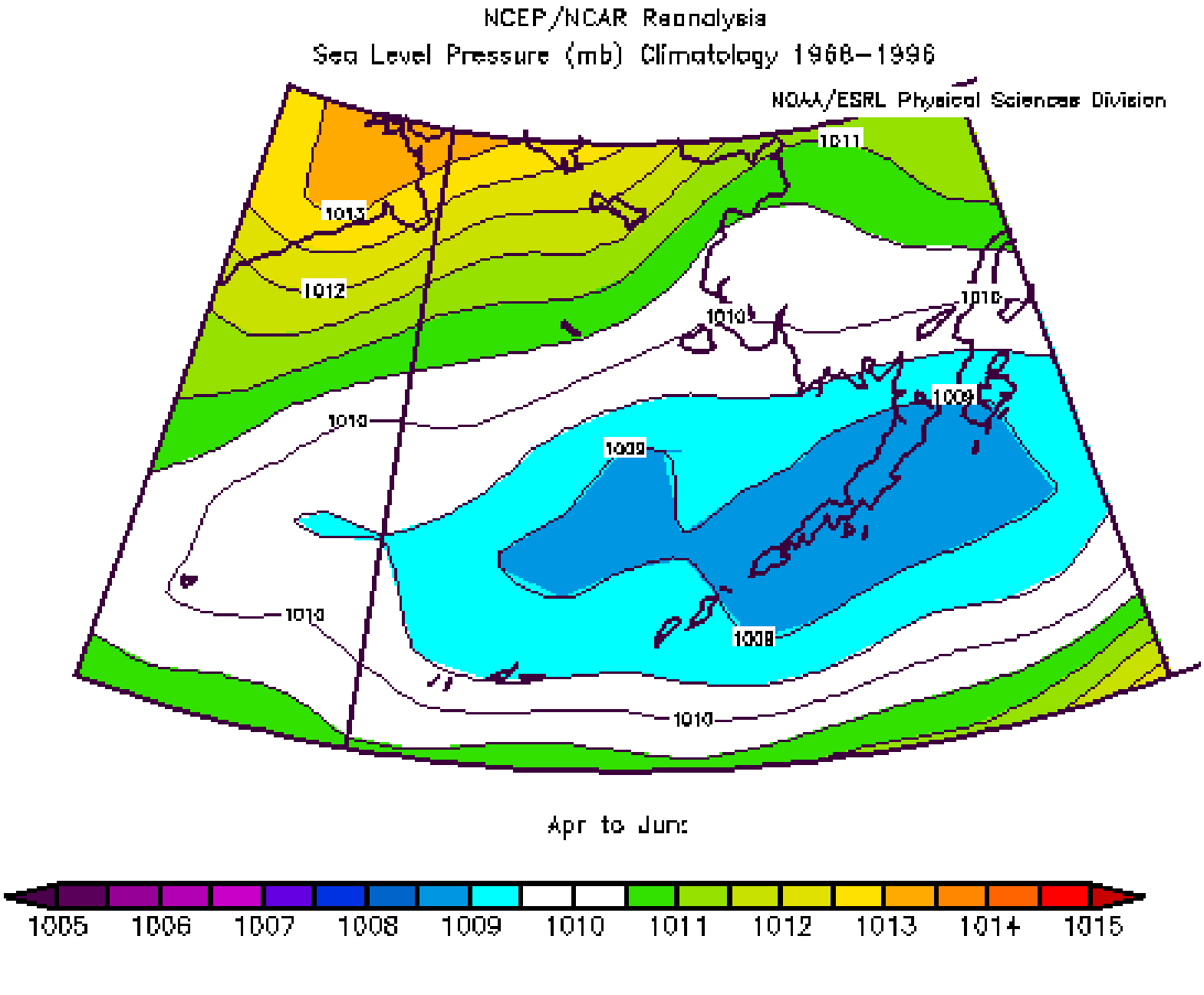





Model Weights
0.25
0.2
0.15
0.1
0.05
0
MRI
GFDL21
GFDL20
UKHAD_C
0
1
2
3
4
5
6
7
8
9
10


Projected Winds: Ensemble & Examples
Weighted Ensemble Mean
GFDL20
GFDL21
MIROC-H
4
3
2
1
0
-1
-2
-3
2000
2005
2010
2015
2020
2025
2030
2035
2040
2045
2050
2055
Year


Mean Spring Winds
1
0.5
0
-0.5
-1
-1.5
1940
1950
1960
1970
1980
1990
2000
2010
Year


NCEP/NCAR Reanalysis
Sea Level Pressure (mb) Climatology 1968-1996
NOAA/ESRL Physical Sciences Division
1011
1013
1012
1010
1010
1009
1010
1009
1008
1010
Apr to Jun
1005
1006
1007
1008
1009
1010
1011
1012
1013
1014
1015

Final Remarks

- Many of the present generation coupled GCMs appear reliable enough to begin making projections for regional ecosystems
- Bayesian model averaging represents a method for constructing model means and uncertainties
- This method can be applied where the climate sensitivity is known, substantial and involves predictable aspects
- These kinds of results complement those from vertically-integrated numerical models.