Future Winds off the Pacific Coast of Canada

Bill Merryfield[1], Badal Pal[1], Eric Salathé[2], Mike Foreman[3],

[1]Canadian Centre for Climate Change Modelling and Analysis, Environment Canada, Victoria

[2]Climate Impacts Group, University of Washington, Seattle

[3]Institute of Ocean Sciences, Fisheries and Oceans Canada, Sidney

Fisheries and Oceans Canada | Pêches et Océans Canada

IOS

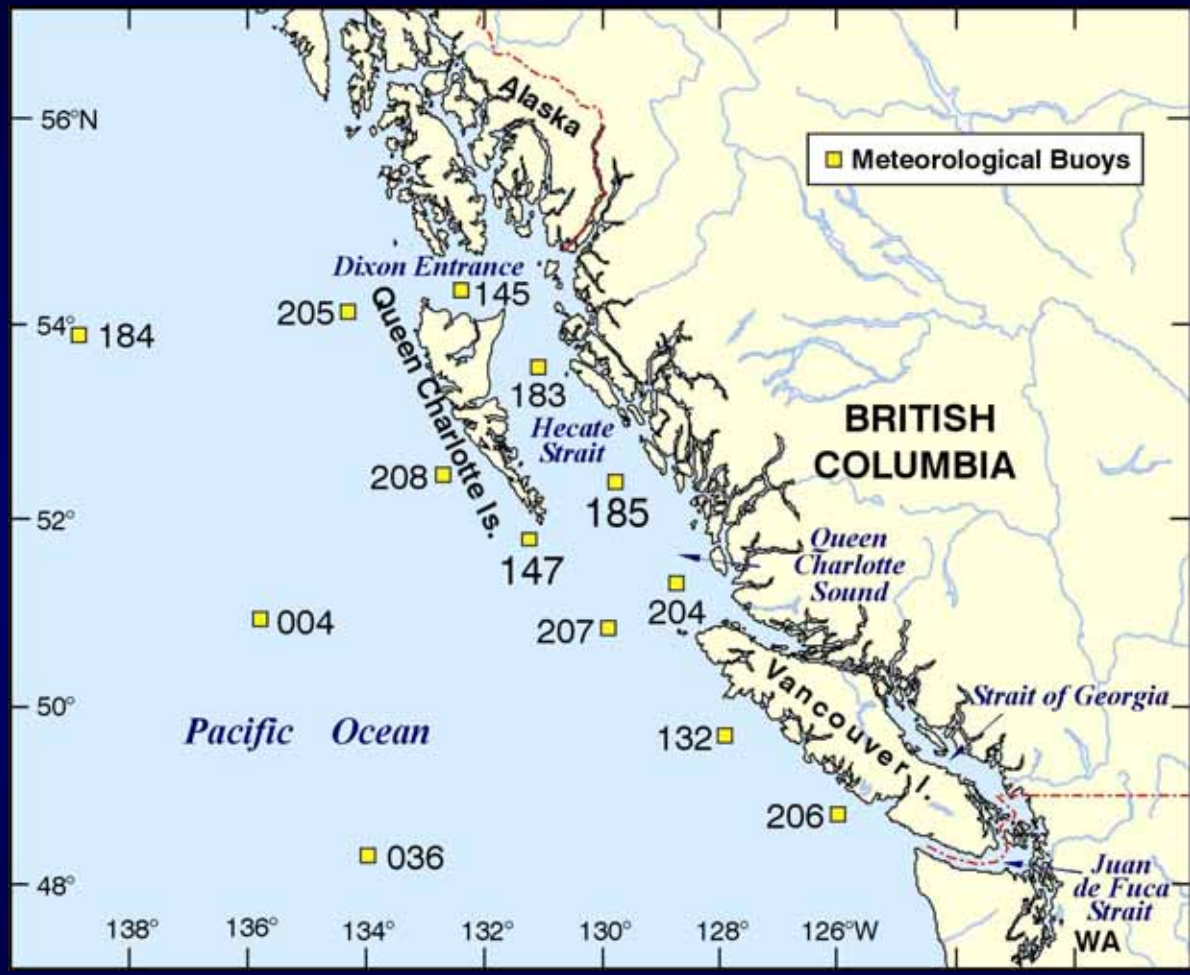
CLIMATE IMPACTS GROUP

CCCma

Environment Canada | Environnement Canada

Outline

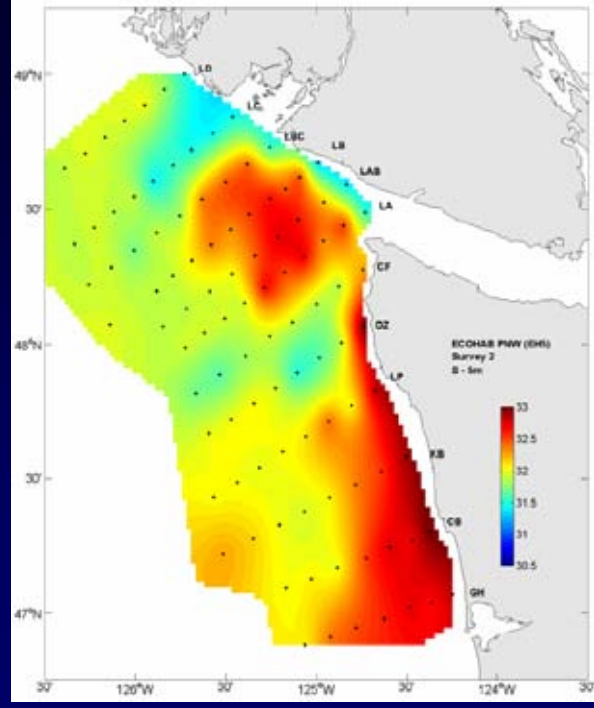
- Motivation
- Methodology
- Model evaluations
- Model projections
- Regional model
- Summary
- Future work



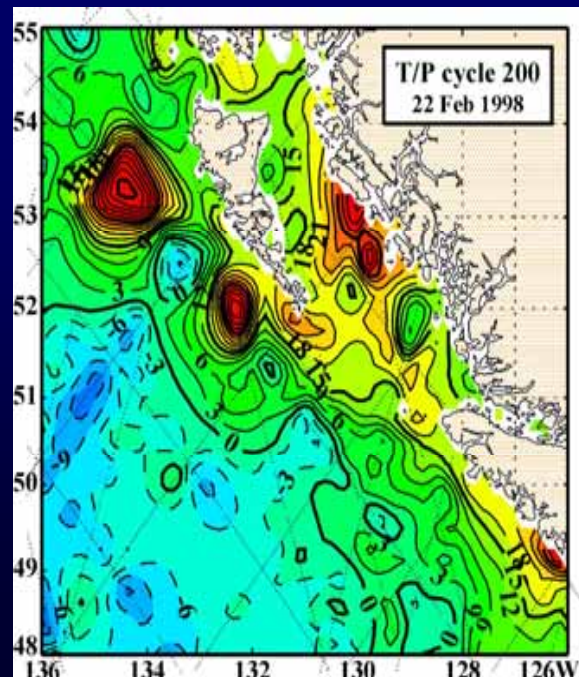
Motivation

- Seasonal winds have important ecosystem impacts off Pacific coast of Canada
  - summer: upwelling & high productivity off SW Vancouver Island (Juan de Fuca Eddy)
  - winter: Haida Eddy generation & nutrient/larvae loss from Hecate Strait & QC Sound

- How are winds projected to change under global warming scenarios ?
  - ecosystem consequences ?



Sept 2005 salinity at 5m depth



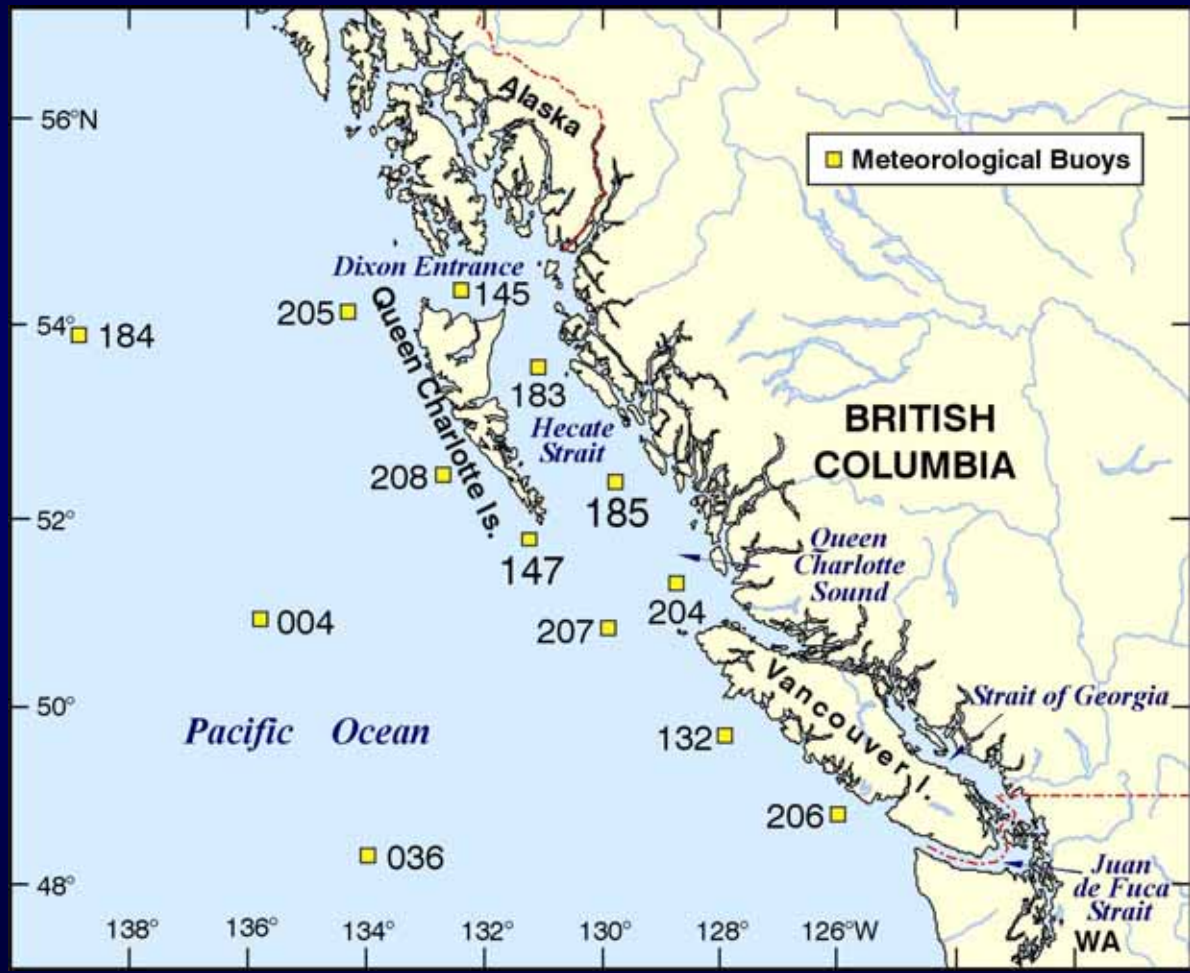
Motivation

(cont'd)

- network of 13 offshore buoys with re-analysis winds back to 1958 (Faucher et al., 1999)

  i. Can evaluate climate model winds over observation period

  ii. Then look at climate model projections



Methodology

- *10m winds from 18 global climate model simulations*
  - *PCMDI web site*
  - *A1B emission scenario*
- *Interpolate, or take nearest value, to buoy locations*
  - *compare monthly & seasonal averages over period 1976-95*
  - *look at projections for 2030-49 and 2080-99*

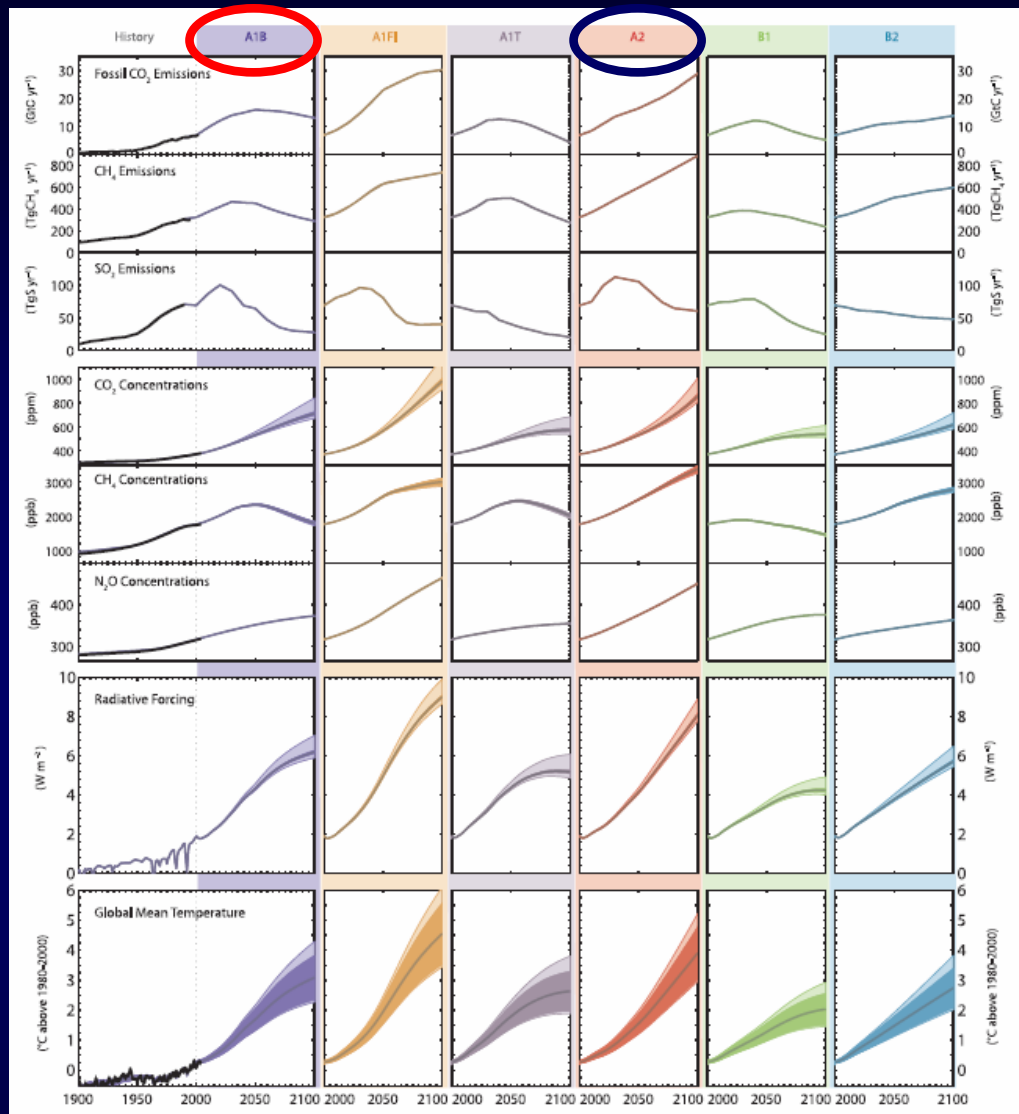
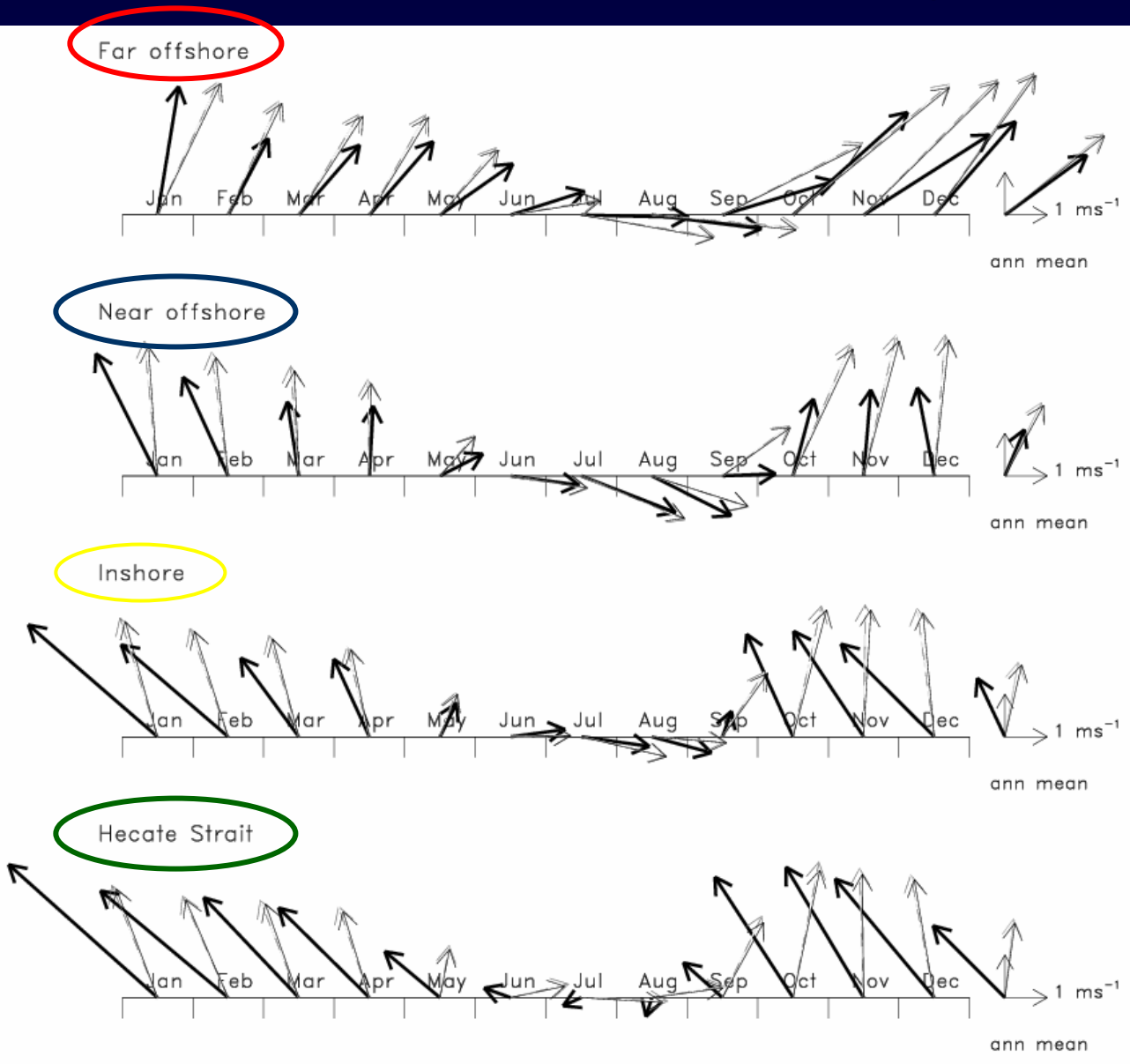


Figure 10.26. *Fossil CO_2, CH_4 and SO_2 emissions for six illustrative SRES non-mitigation emission scenarios, their corresponding CO_2, CH_4 and N_2O concentrations, radiative forcing and global mean temperature projections based on an SCM tuned to 19 AOGCMs. The dark shaded areas in the bottom temperature panel represent the mean ±1 standard deviation for the 19 model tunings. The lighter shaded areas depict the change in this uncertainty range, if carbon cycle feedbacks are assumed to be lower or higher than in the medium setting. Mean projections for mid-range carbon cycle assumptions for the six illustrative SRES scenarios are shown as thick coloured lines. Historical emissions (black lines) are shown for fossil and industrial CO_2 (Marland et al., 2005), for SO_2 (van Aardenne et al., 2001) and for CH_4 (van Aardenne et al., 2001, adjusted to Olivier and Berdowski, 2001). Observed CO_2, CH_4 and N_2O concentrations (black lines) are as presented in Chapter 6. Global mean temperature results from the SCM for anthropogenic and natural forcing compare favourably with 20th-century observations (black line) as shown in the lower left panel (Folland et al., 2001; Jones et al., 2001; Jones and Moberg, 2003).*

1976-95 Evaluation of Ensemble Monthly Averages



- ***Seasonal direction changes captured reasonably well***
- ***Far offshore & near offshore model speeds too strong by 20-40%***
  - ***Model winds should have "fast bias" as they are at 10m vs 5m for buoy winds***

1976-95 Summer Evaluation of Individual Models

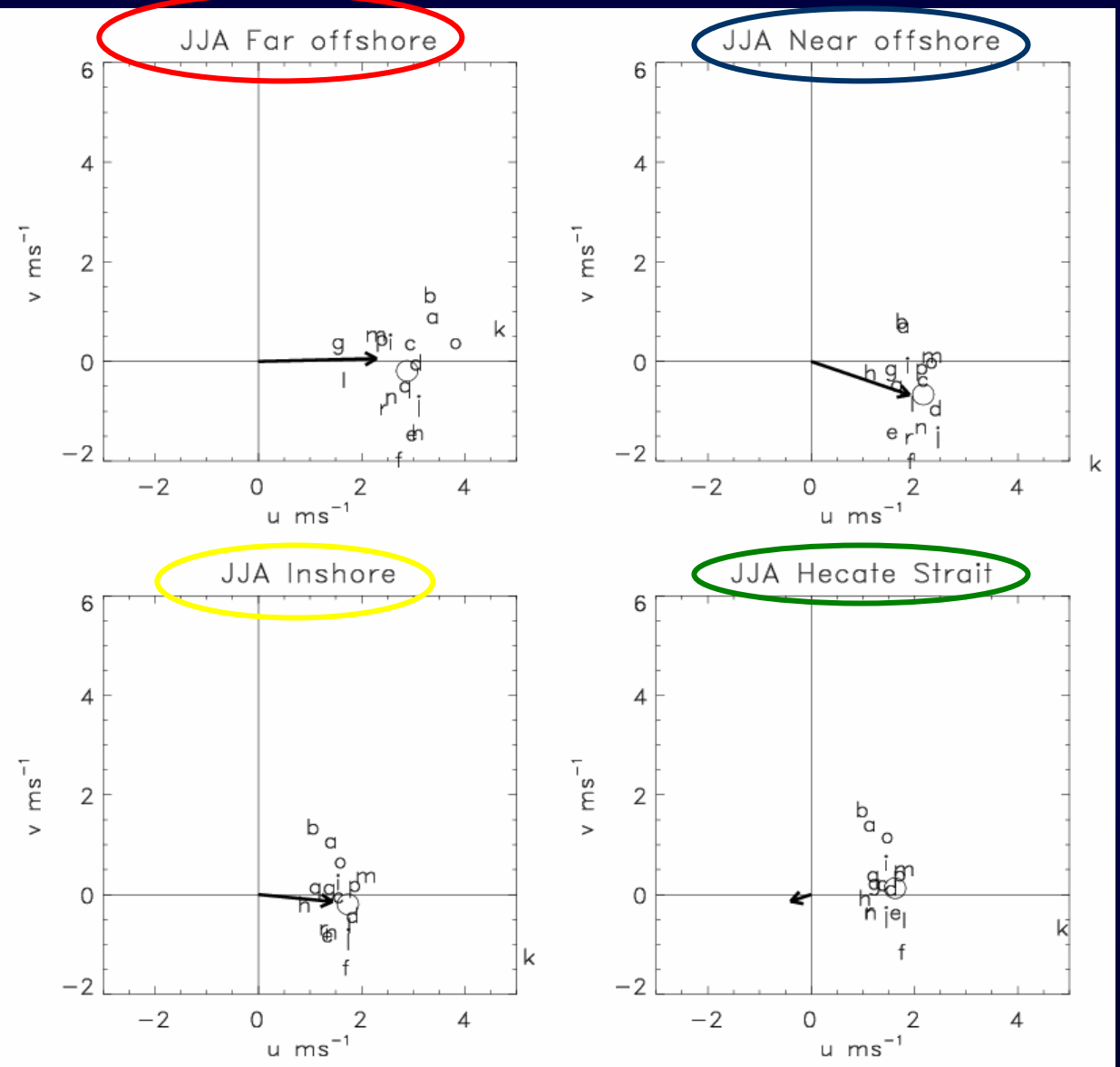


Table 1: Climate models used in this study and their atmospheric resolutions

Symbol	Institution/Model	Atmospheric resolution	Horiz grid dimensions lon × lat
a	BCCR/BCM2.0	T63L31	128 x 64
b	CCCMA/CGCM3.1(T47)	T47L31	96 x 48
c	CCCMA/CGCM3.1(T63)	T63L31	128 x 64
d	CCSR/MIROC3.2(med)	T42L20	128 x 64
e	CNRM/CM3	T63L45	128 x 64
f	CSIRO/Mk3.5	T63L18	192 x 96
g	GFDL/CM2.0	2.5° × 2°L2	144 x 90
h	GFDL/CM2.1	2.5° × 2°L24	144 x 90
i	GISS/AOM	4° × 3°L12	90 x 60
j	GISS/EH	5° × 4°L20	72 x 46
k	GISS/ER	5° × 4°L20	72 x 46
l	INM/CM3.0	5° × 4°L21	72 x 45
m	IPSL/CM4	2.5° × 3.75°L19	96 x 72
n	MIUB/ECHO-G	T30L19	96 x 48
o	MPI/ECHAM5	T63L31	192 x 96
p	MRI/CGCM2.3.2	T42L30	128 x 64
q	UKMO/HadCM3	3.75° × 2.5°L19	96 x 72
r	UKMO/HadGEM1	1.875° × 1.25°L38	192 x 144

1976-95 Winter Evaluation of Individual Models

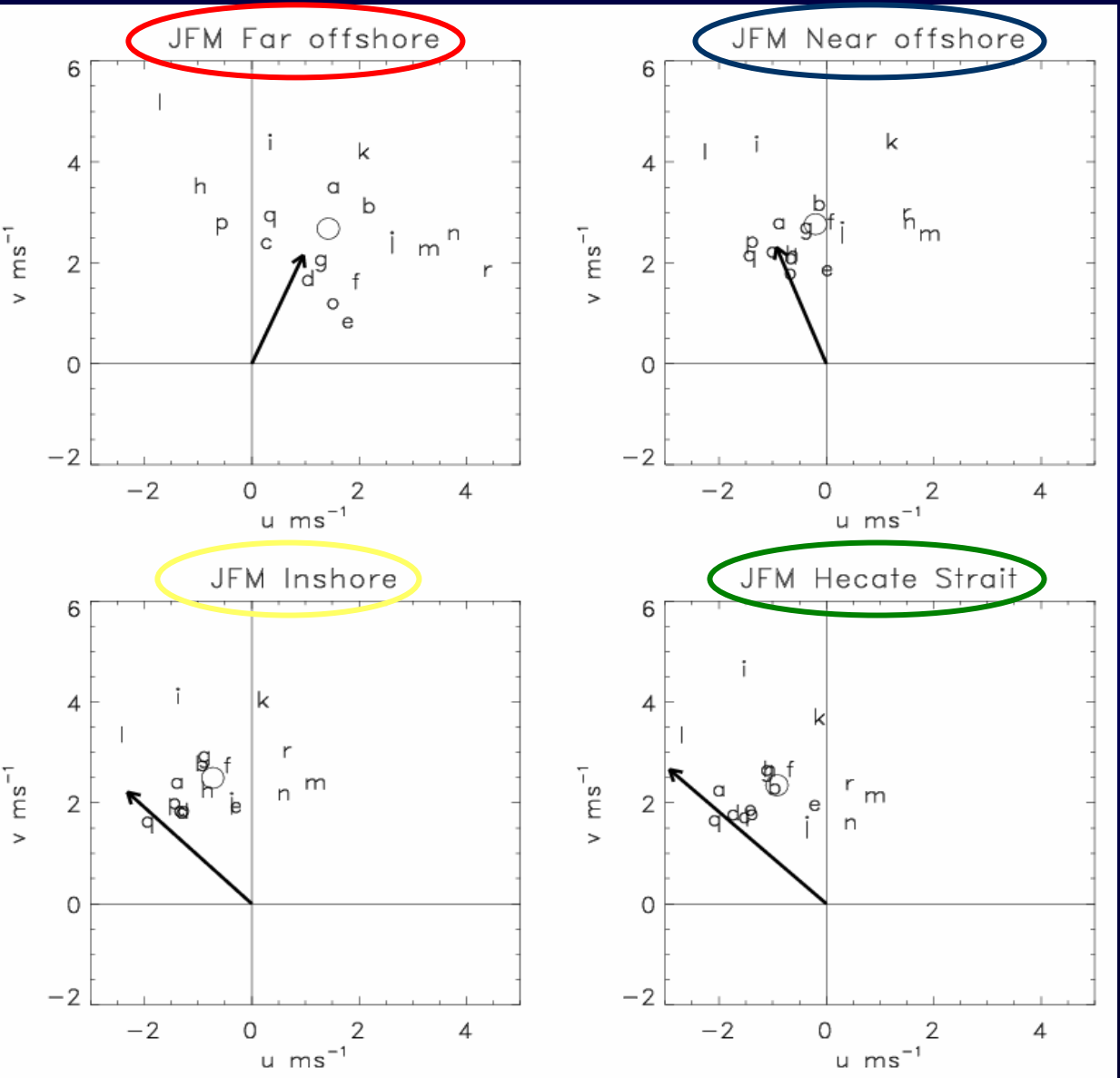


Table 1: Climate models used in this study and their atmospheric resolutions

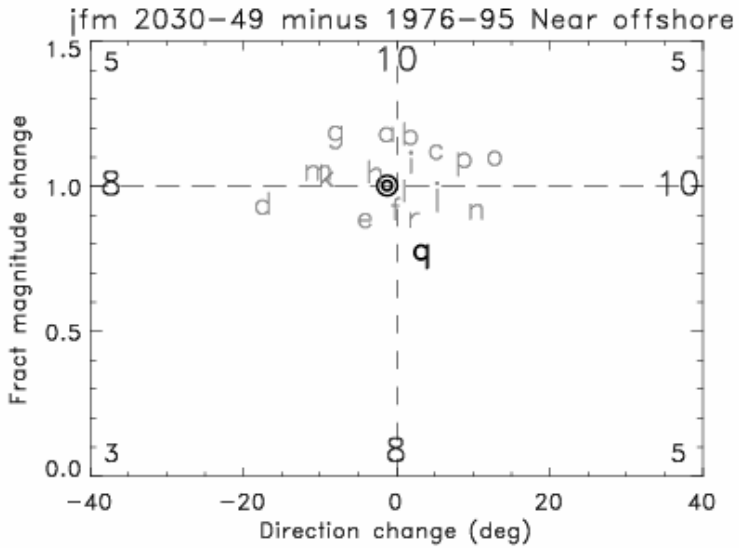
Symbol	Institution/Model	Atmospheric resolution	Horiz grid dimensions lon × lat
a	BCCR/BCM2.0	T63L31	128 x 64
b	CCCMA/CGCM3.1(T47)	T47L31	96 x 48
c	CCCMA/CGCM3.1(T63)	T63L31	128 x 64
d	CCSR/MIROC3.2(med)	T42L20	128 x 64
e	CNRM/CM3	T63L45	128 x 64
f	CSIRO/Mk3.5	T63L18	192 x 96
g	GFDL/CM2.0	2.5° × 2°L2	144 x 90
h	GFDL/CM2.1	2.5° × 2°L24	144 x 90
i	GISS/AOM	4° × 3°L12	90 x 60
j	GISS/EH	5° × 4°L20	72 x 46
k	GISS/ER	5° × 4°L20	72 x 46
l	INM/CM3.0	5° × 4°L21	72 x 45
m	IPSL/CM4	2.5° × 3.75°L19	96 x 72
n	MIUB/ECHO-G	T30L19	96 x 48
o	MPI/ECHAM5	T63L31	192 x 96
p	MRI/CGCM2.3.2	T42L30	128 x 64
q	UKMO/HadCM3	3.75° × 2.5°L19	96 x 72
r	UKMO/HadGEM1	1.875° × 1.25°L38	192 x 144

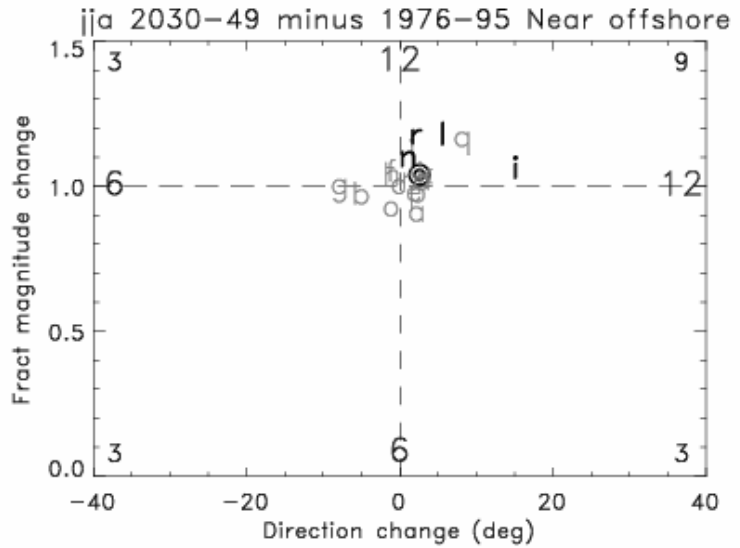
Projected Changes at Near offshore Buoys

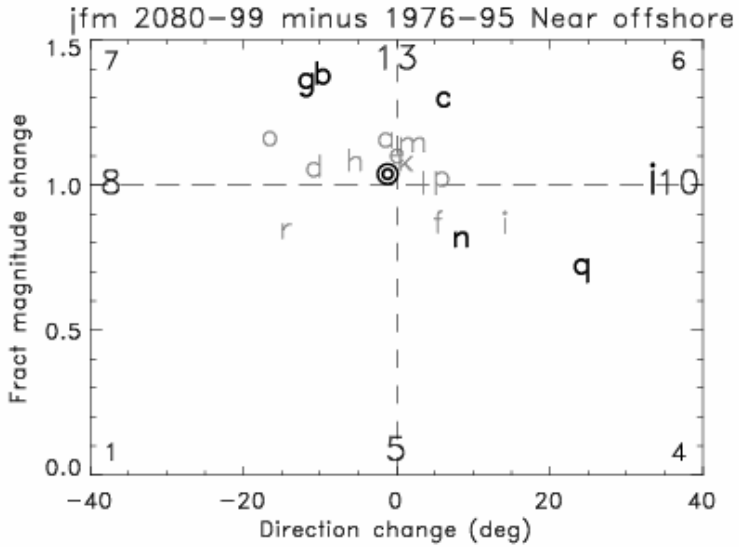
winter **summer**

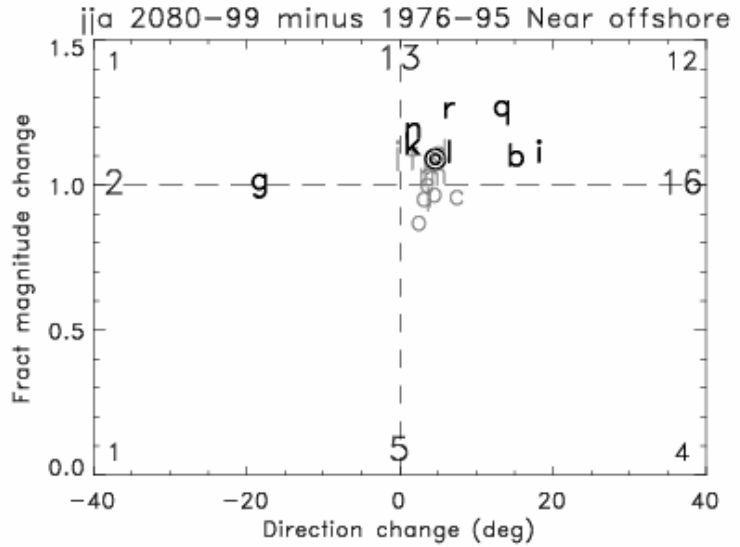
2030-49

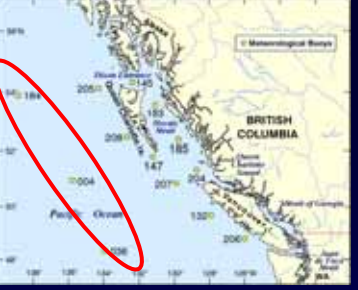
2080-99









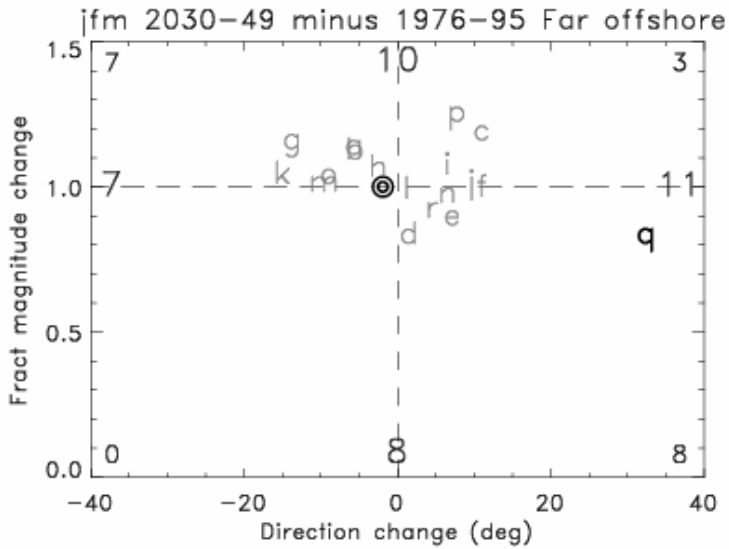


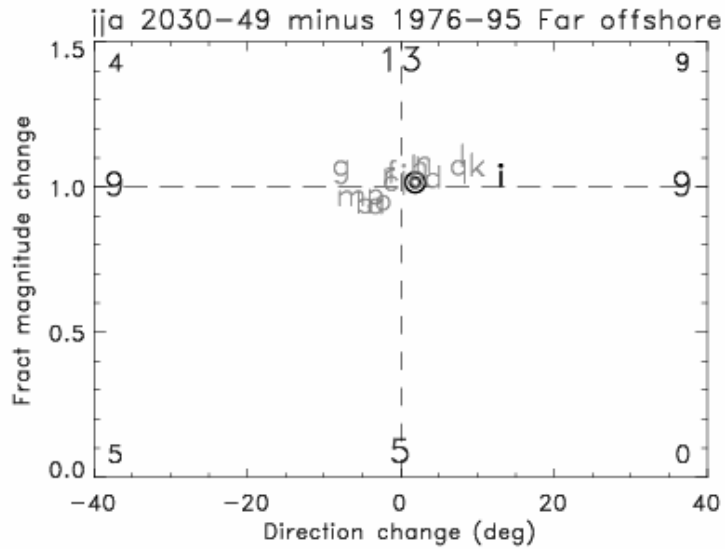
Projected Changes at Far offshore Buoys

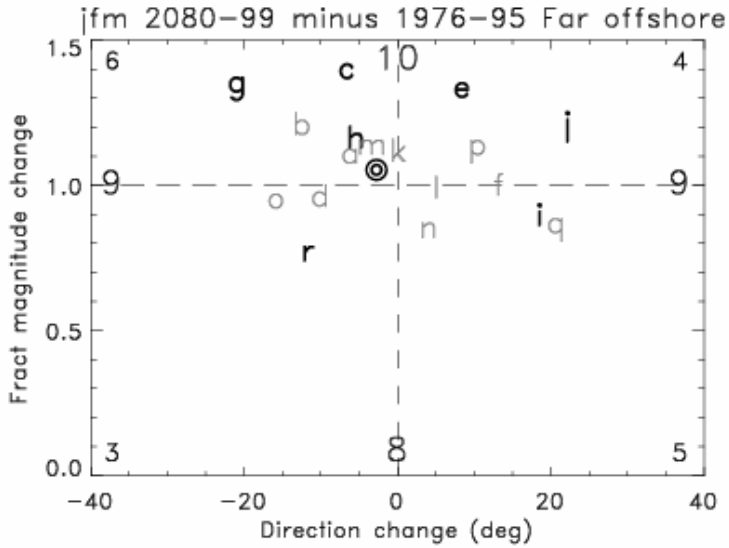
winter **summer**

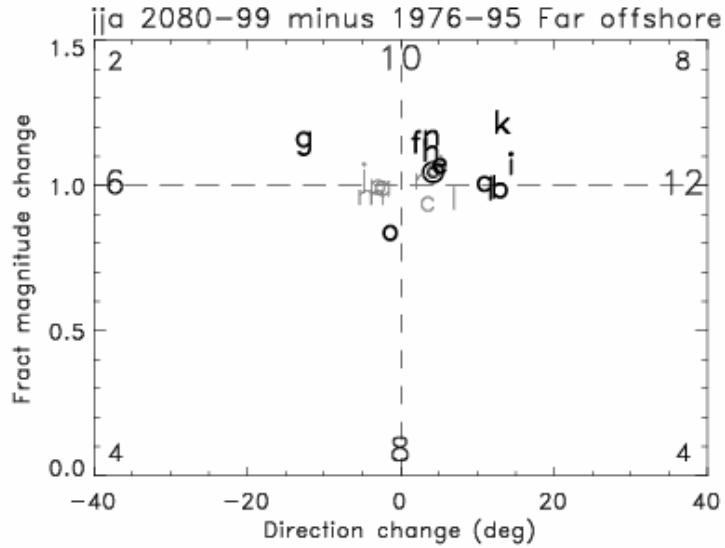
2030-49

2080-99



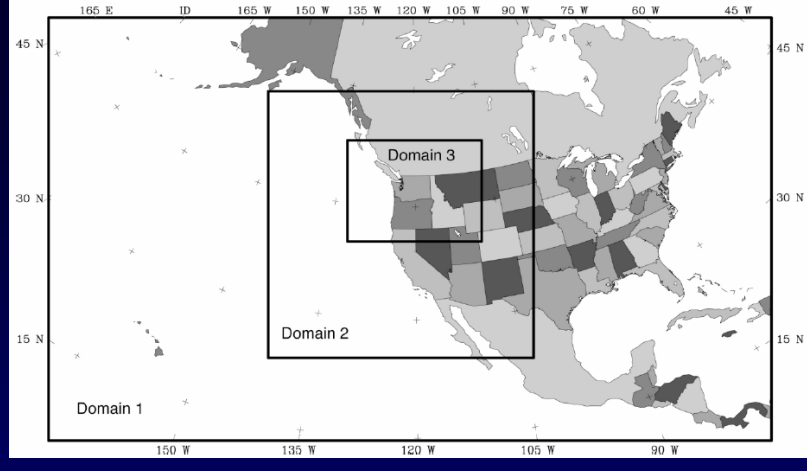






Regional Climate Model for the Pacific Northwest

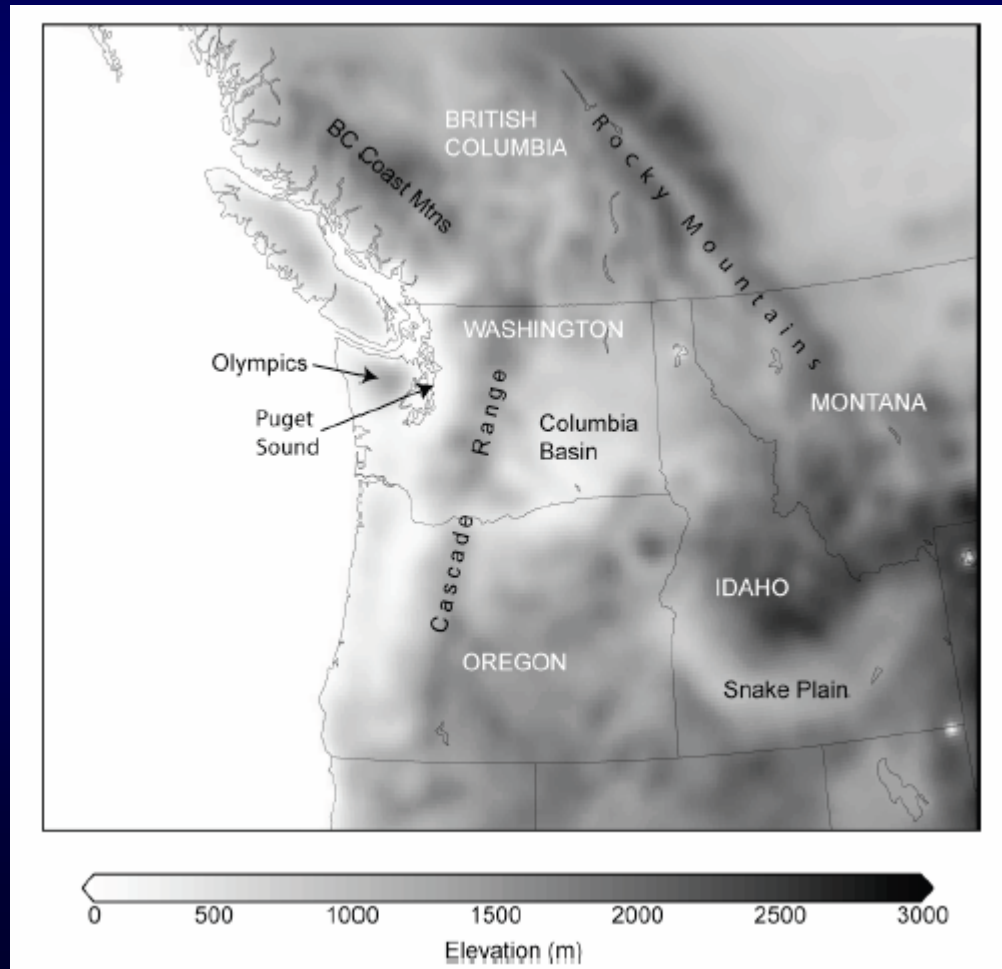
Salathé et al (2008)



- Should do much better job of capturing interactions & feedbacks from meso-scale processes

- 15km regional climate model for PNW nested in ECHAM5 (ECMWF & Max Planck) global model
  - A2 scenario

- better resolution of regional topography
  - but atmosphere-only
  - no regional ocean



Regional Model Projections: Pressure & Winds

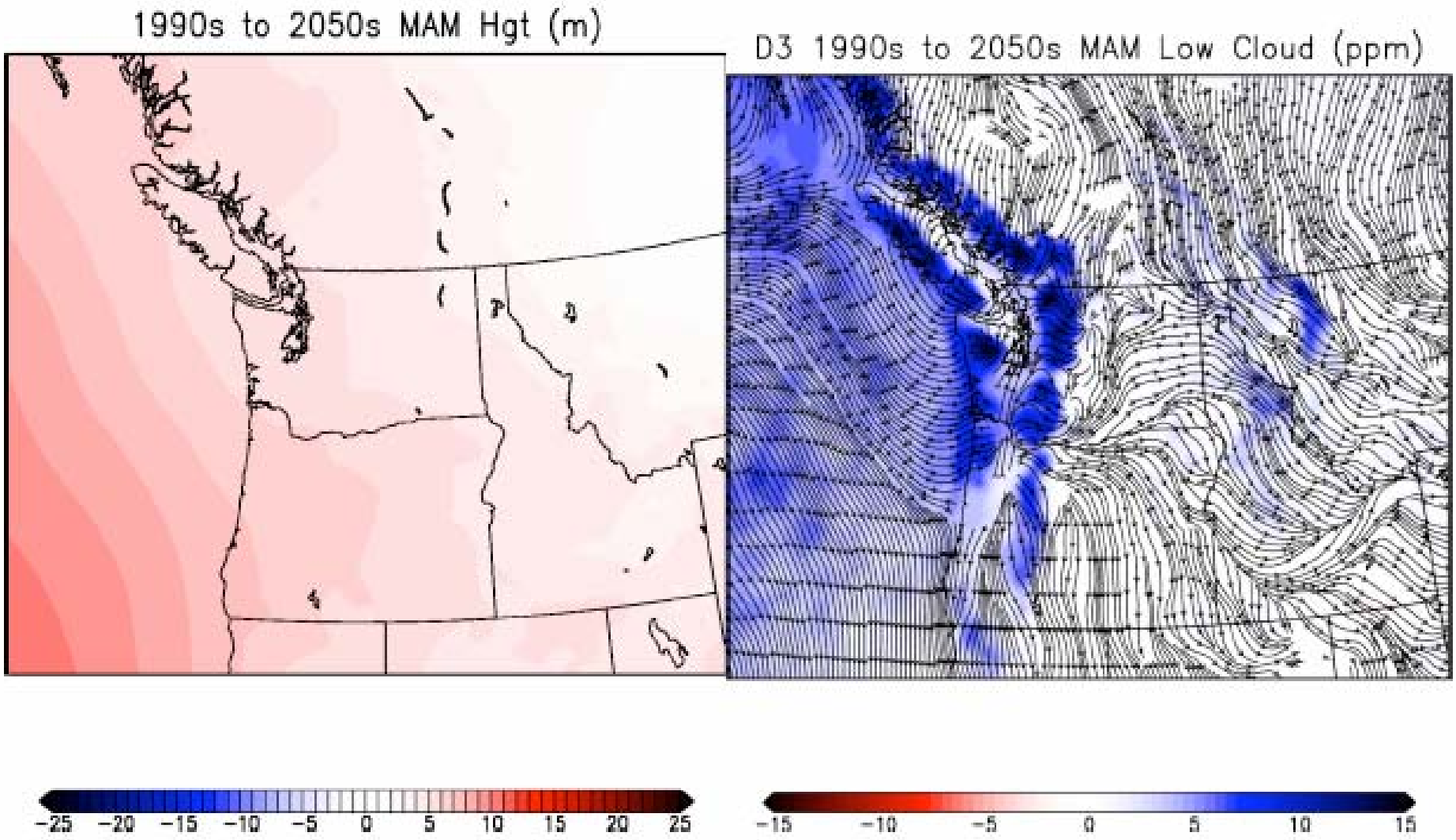


Figure 13. Simulated MAM changes from 1989-1999 to 2045-2054 for a) 850-hPa heights (m) b) integrated cloud water (ppmv) and surface wind.

Summary

- on average, global climate model winds off BC
  - capture observed seasonal changes reasonably well
  - but speeds are too strong by 20-40%

- Model projections:
  - Winter – 1 model shows statistically significant changes from 1976-95 to 2030-49 & only about 1/3 are significant to 2080-99
  - Summer – few individual model changes are significant from 1976-95 to 2030-49 but ensemble mean is, with 2-4% larger speeds & ≈ 2° clockwise rotation
    - for 1976-95 to 2080-99 changes similar – 4-9% larger speeds & 4° clockwise rotation

- Salathé et al. regional model predicts March-May winds will have stronger upwelling components off BC
  - Yet to be evaluated

Future Work

- off southern California, stronger upwelling winds predicted to win out over warmer surface waters & stronger stratification (Auad et al, 2006)

- But off BC, stratification determined more by salinity

- Changes in precipitation & river discharge will be important

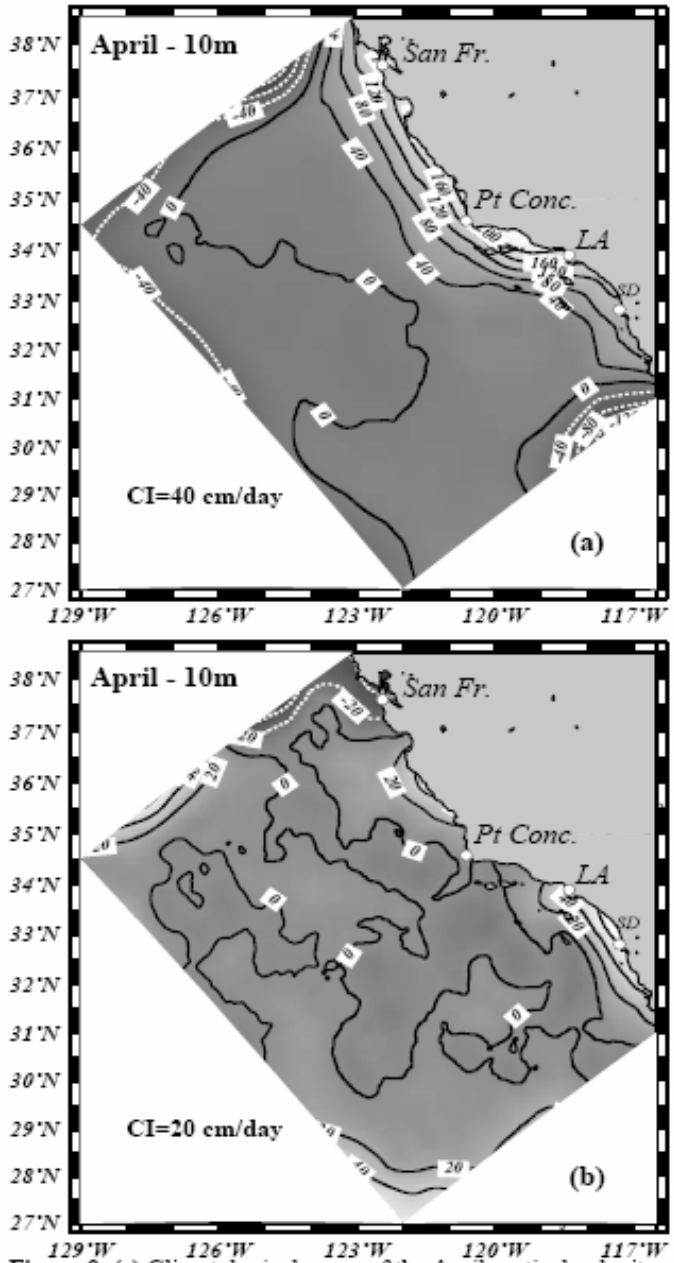


Figure 9. (a) Climatological mean of the April vertical velocity at 10 m (units are cm/day). (b) Climatological change of the April vertical velocity at 10 m (units are cm/day).

Precipitation & Fraser River Projected Changes

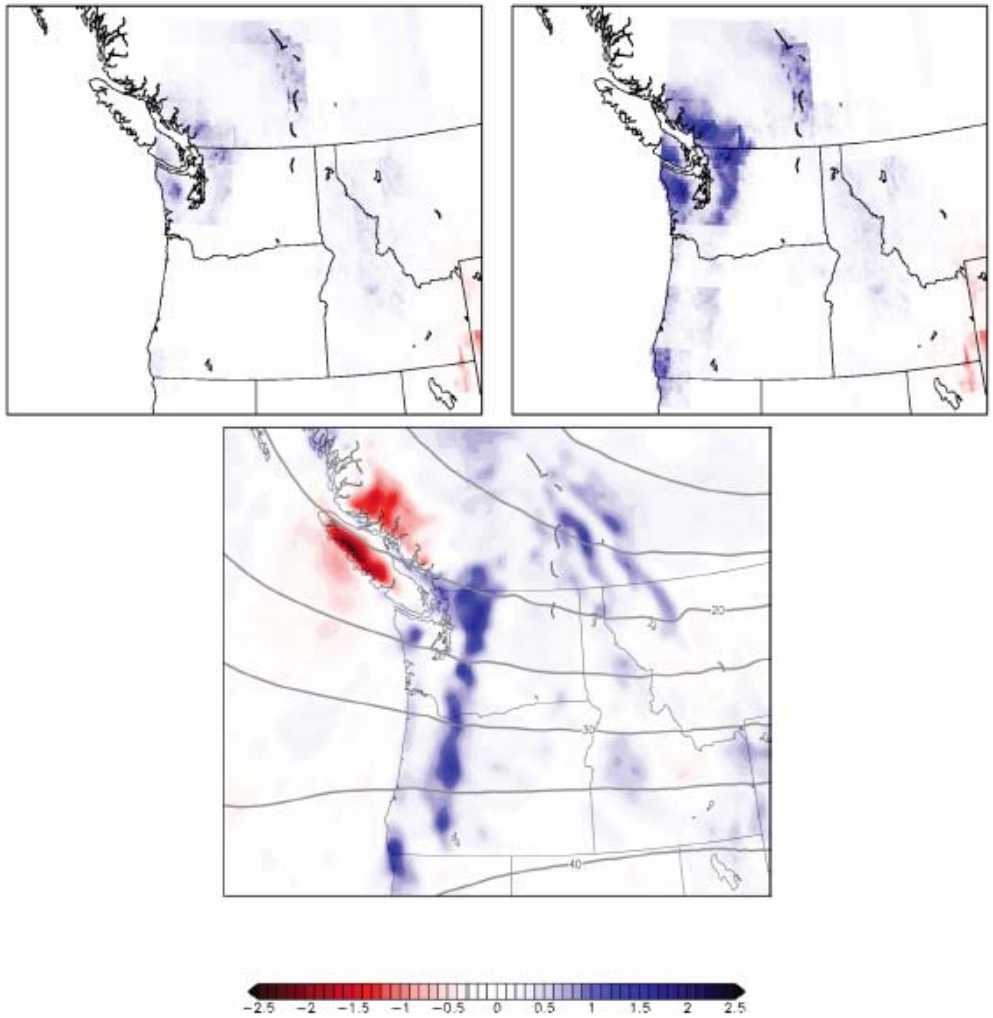
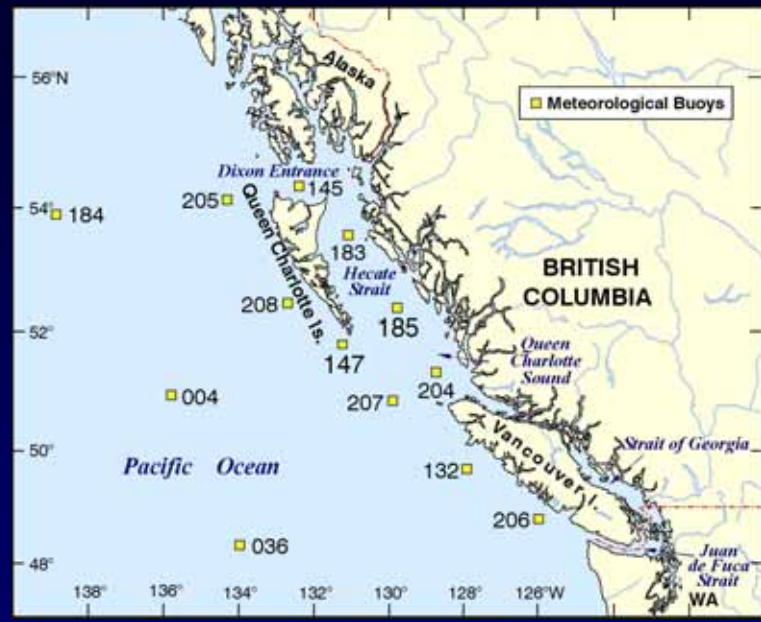
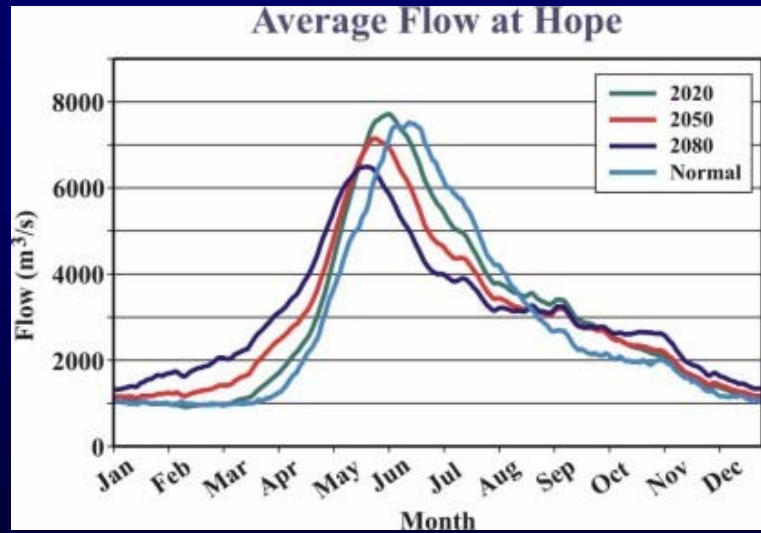


Figure 15. Change in precipitation (mm/day) for SON season from 1989-1999 to 2045-2054 for a) downscaling with precipitation only b) downscaling with precipitation and sea-level pressure c) regional model.





Fraser River hydrograph
Morrison et al, 2002


Gracias por su interes!