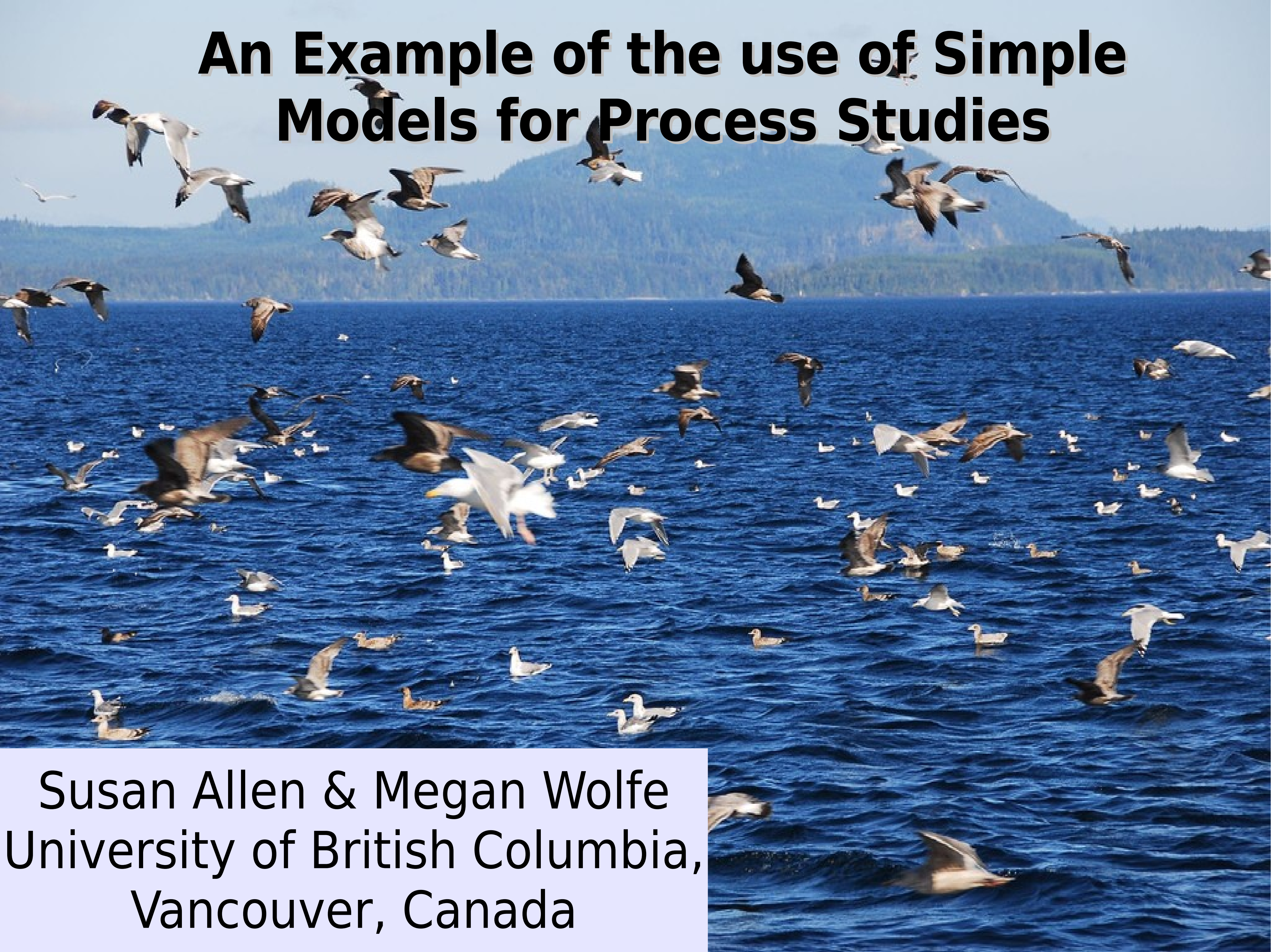
An Example of the use of Simple Models for Process Studies



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University of British Columbia,
Vancouver, Canada

Simple versus Sophisticated

Fast

Focussed

Easier to Interpret

Easier to DeBug

Simulates all the processes that could be important

Spatially detailed

Valid for multiple questions – a flexible tool

Outline

The problem

The model

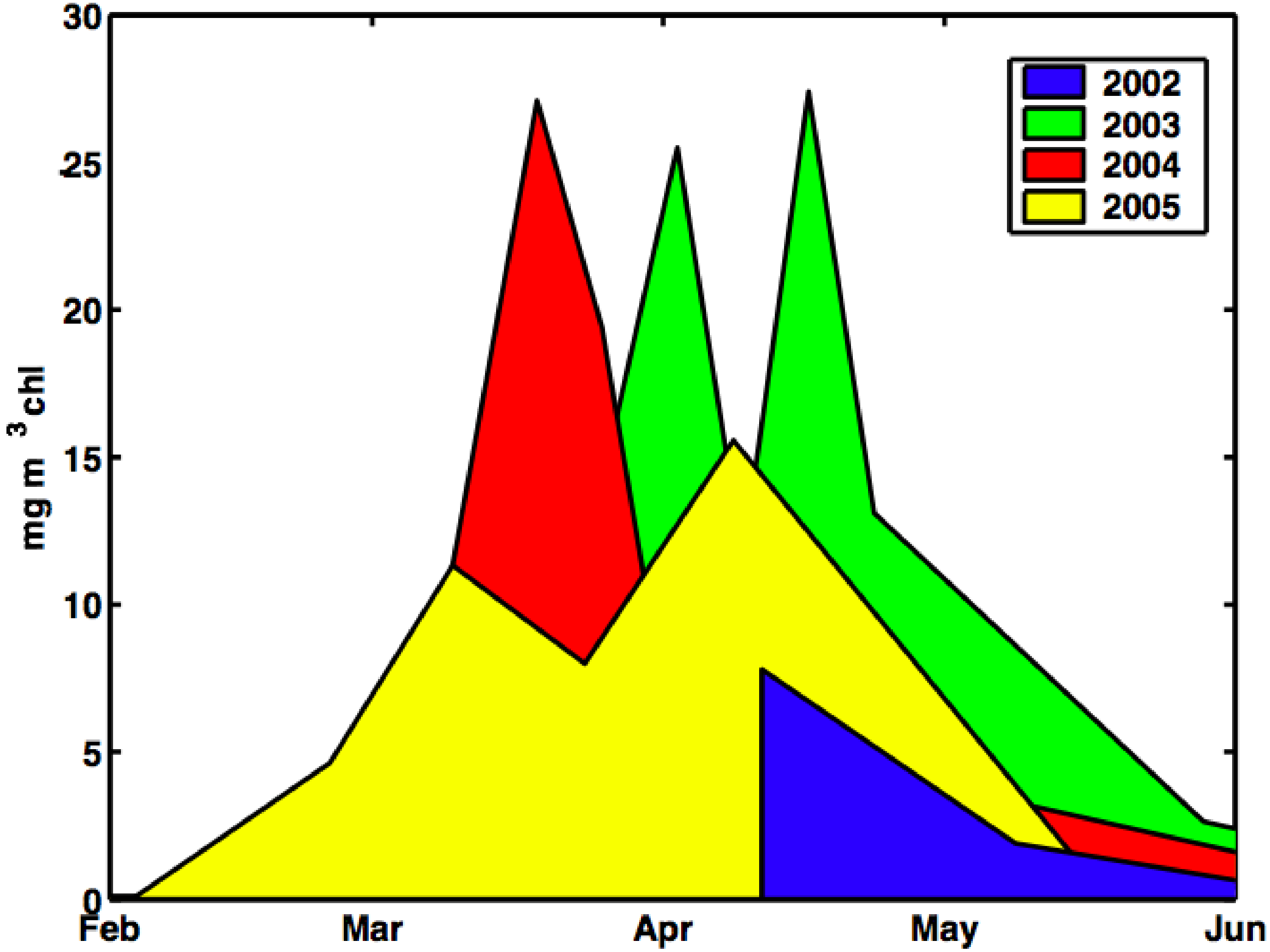
The results

The limitations

Comments on the model

Conclusions

Interannual Variation in the Timing of the Spring Bloom in the Strait of Georgia

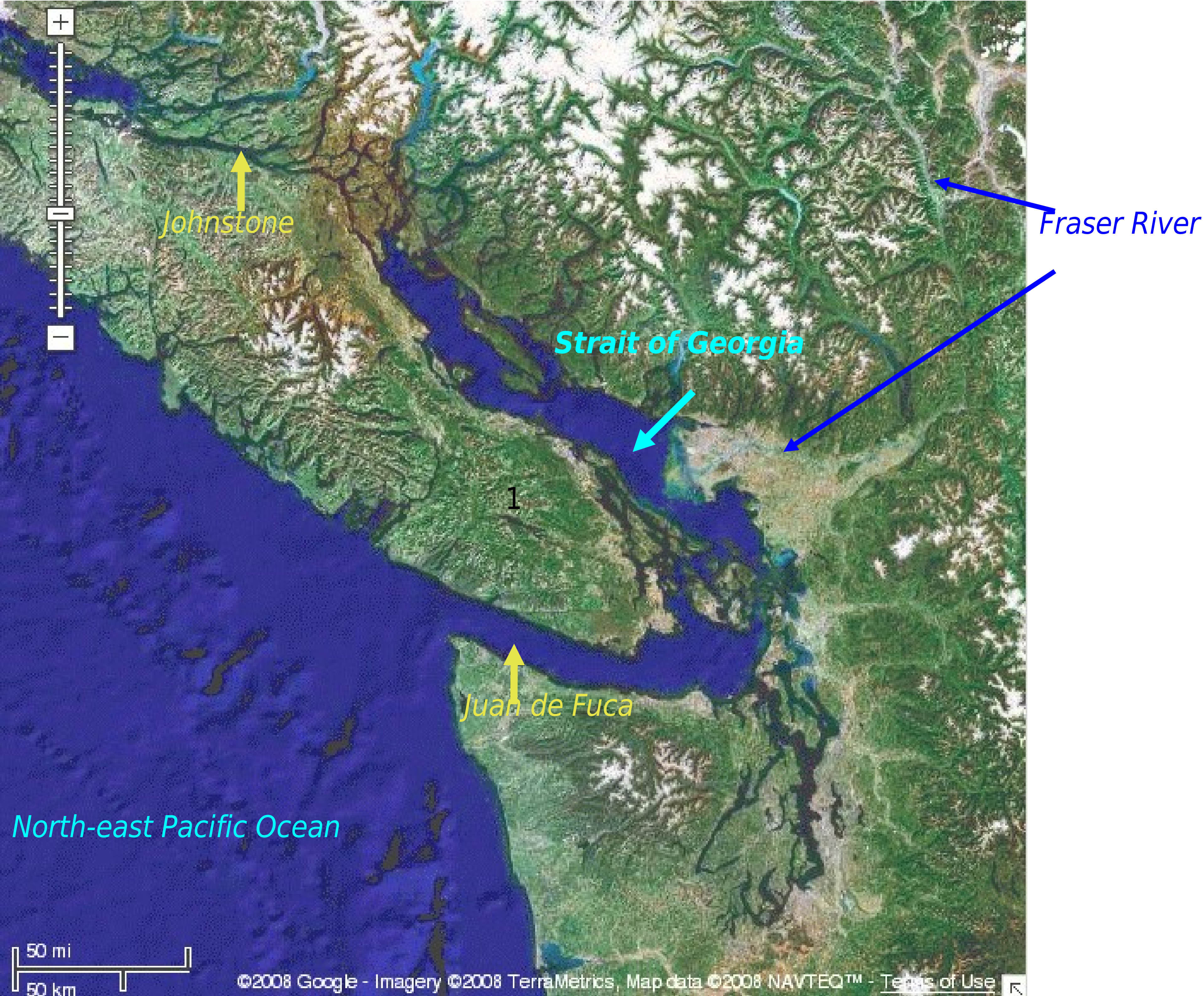


Match-Mismatch

Timing of the spring phytoplankton bloom seems to affect the strength of the *Neocalanus plumchrus* bloom

If the bloom is very early (2005), the copepod misses the initial highly nutritious plankton and molting from 3 stage appears to fail (Sastri and Dower, 2009)

Neocalanus p. is usually a dominant copepod and thought to be important food for juvenile salmon


Johnstone
Strait of Georgia
Fraser River
1
Juan de Fuca
North-east Pacific Ocean
50 mi
50 km
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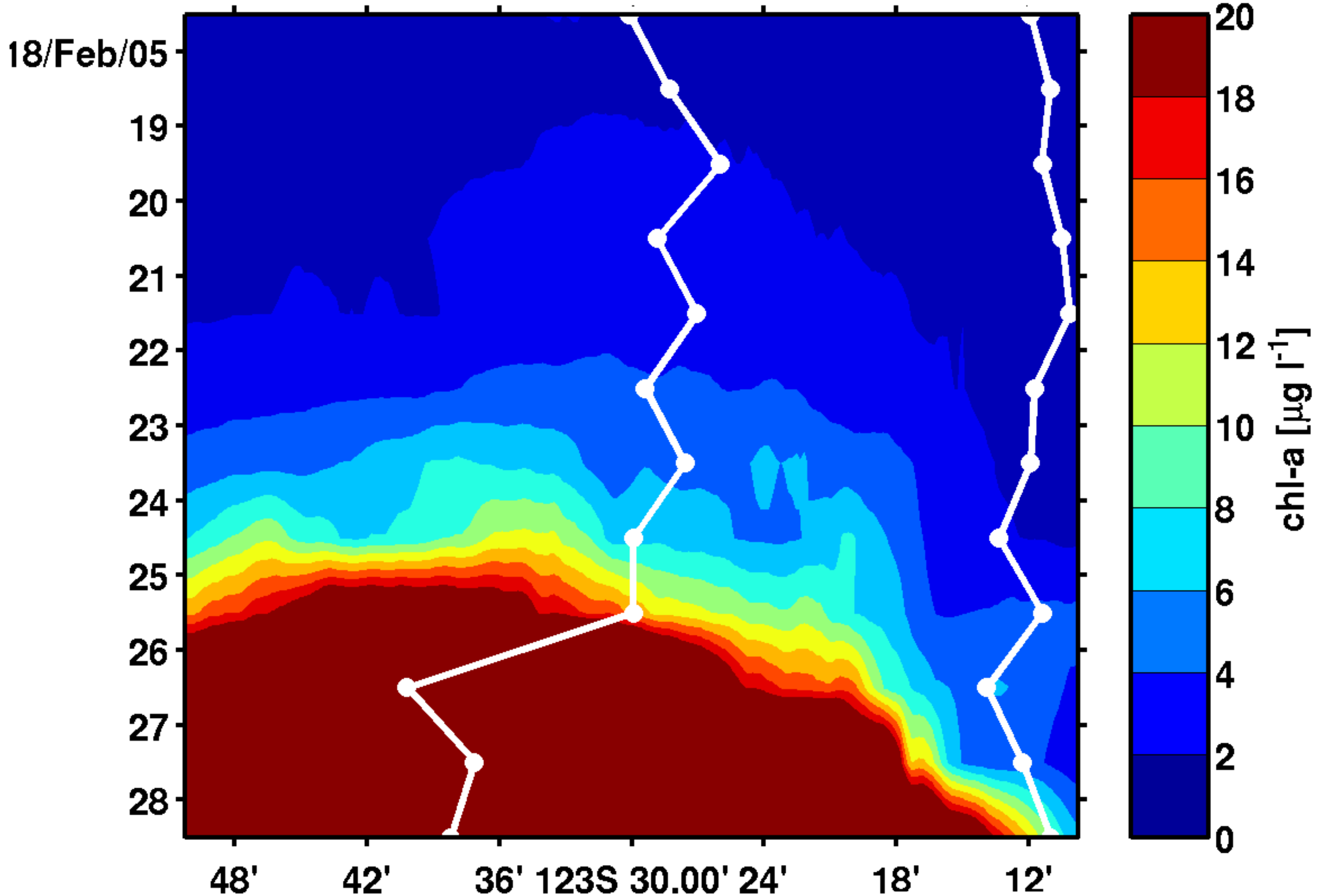
The model protocol

Carefully model the upper 15 m of the Strait, particularly the light and mixing

Use a simple biological model with only one tuned parameter and see if it matches the 4 measured spring blooms

Use this model to investigate the dynamics of the spring bloom and hindcast the last 30 years (and forecast yearly blooms)

Spring Bloom along the Ferry Route



Mark Halverson

One-dimensional Mixing Model plus

Using a 1-dimensional model allows detailed vertical resolution and runs quickly

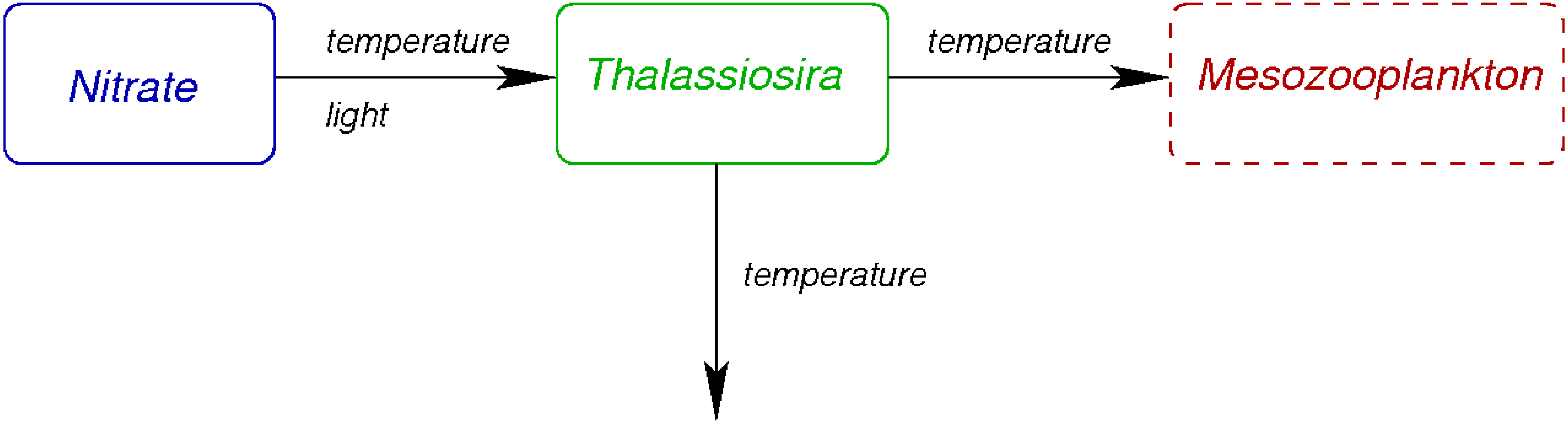
All two-dimensional processes must be parameterized

Use the KPP mixing layer model

Add baroclinic pressure gradients (due to finite size of the Strait)

Add estuarine circulation

Forced with hourly winds, clouds etc. and daily river flows



dP/dt = growth – mortality – grazing - sinking + physics

Growth : Needs nitrate and light

Mortality : set to a constant

Grazing : a function of observed zooplankton biomass

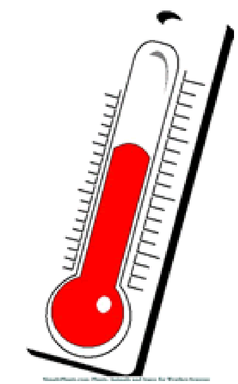
Sinking : diatoms heavy

Spring Bloom : Light for Growth versus Loses

Critical depth theory with two provisos

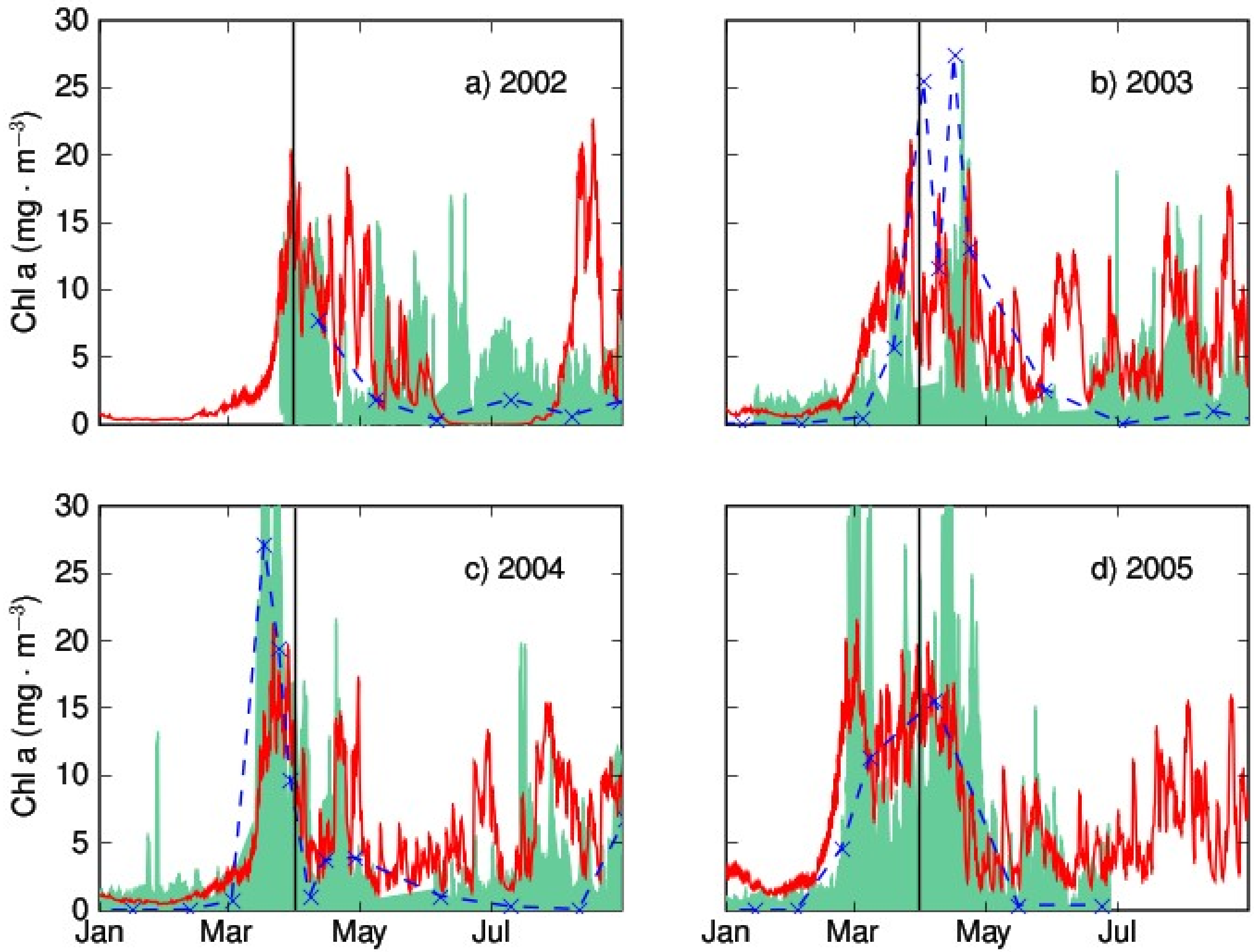
Mixing layer depth (not mixed layer depth)

Need to include large advective loses



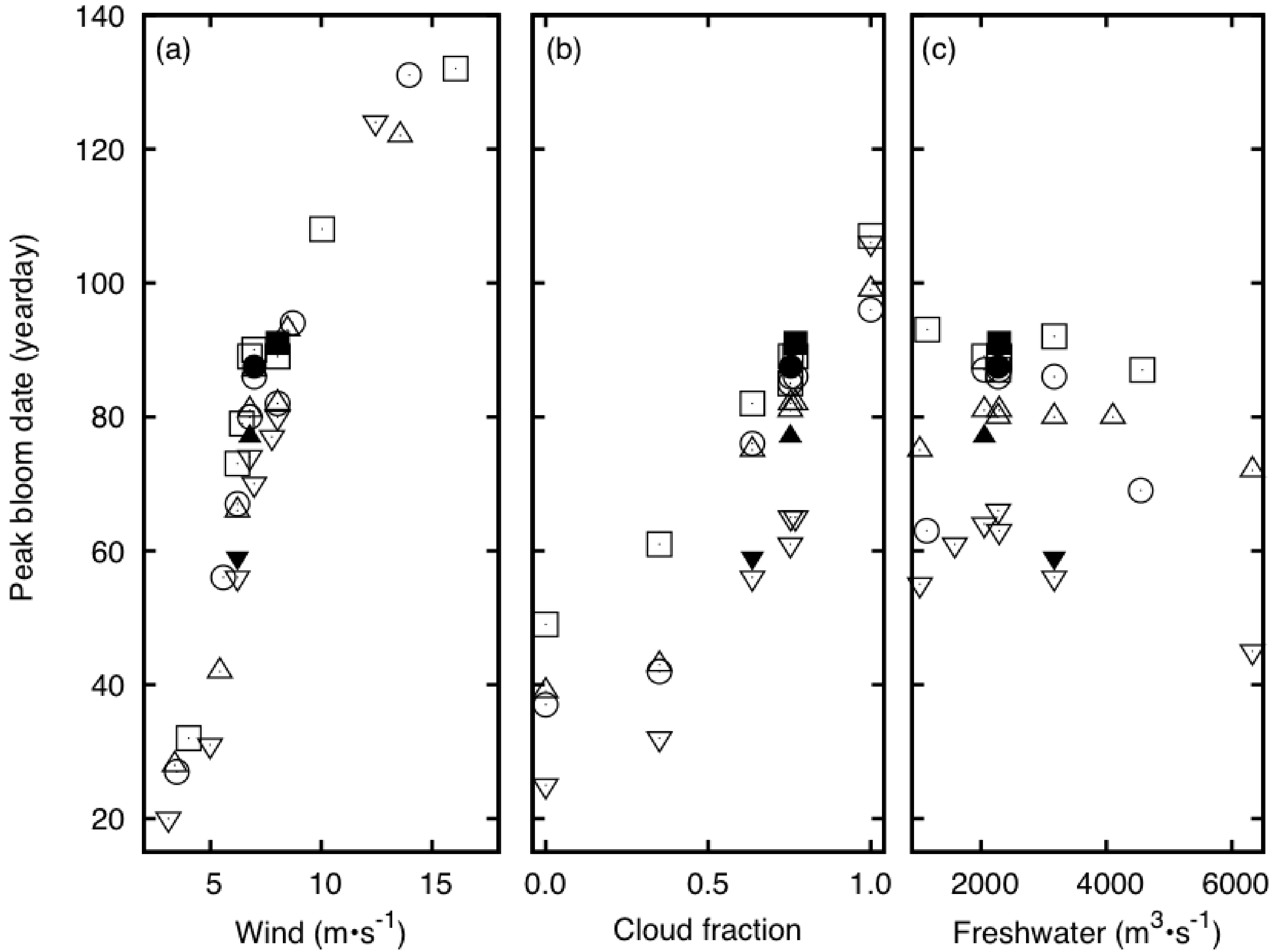
Wind Clouds River Flow Temperature

Ferry chl fluor., Surface chl > 20 m, Surface model chl



Ferry chl unscaled between years

Timing of Spring Bloom is most sensitive to wind strength and then to cloud fraction.



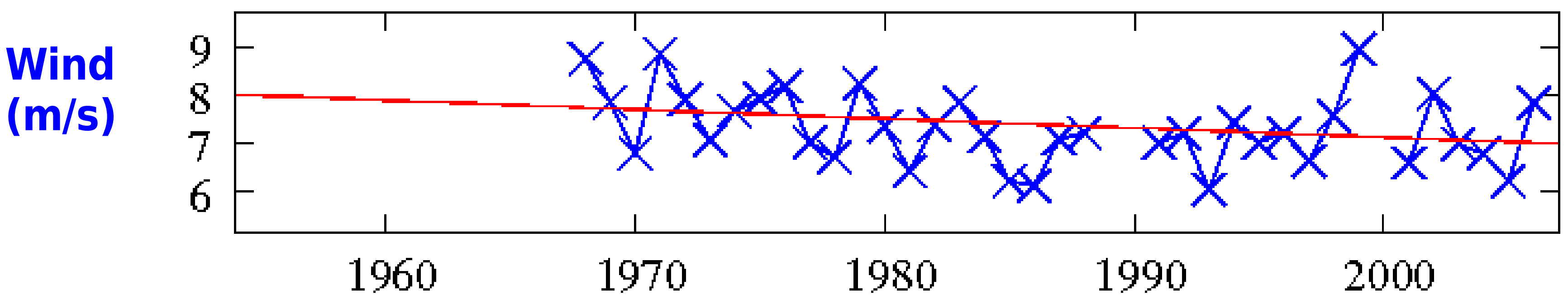
Hindcast

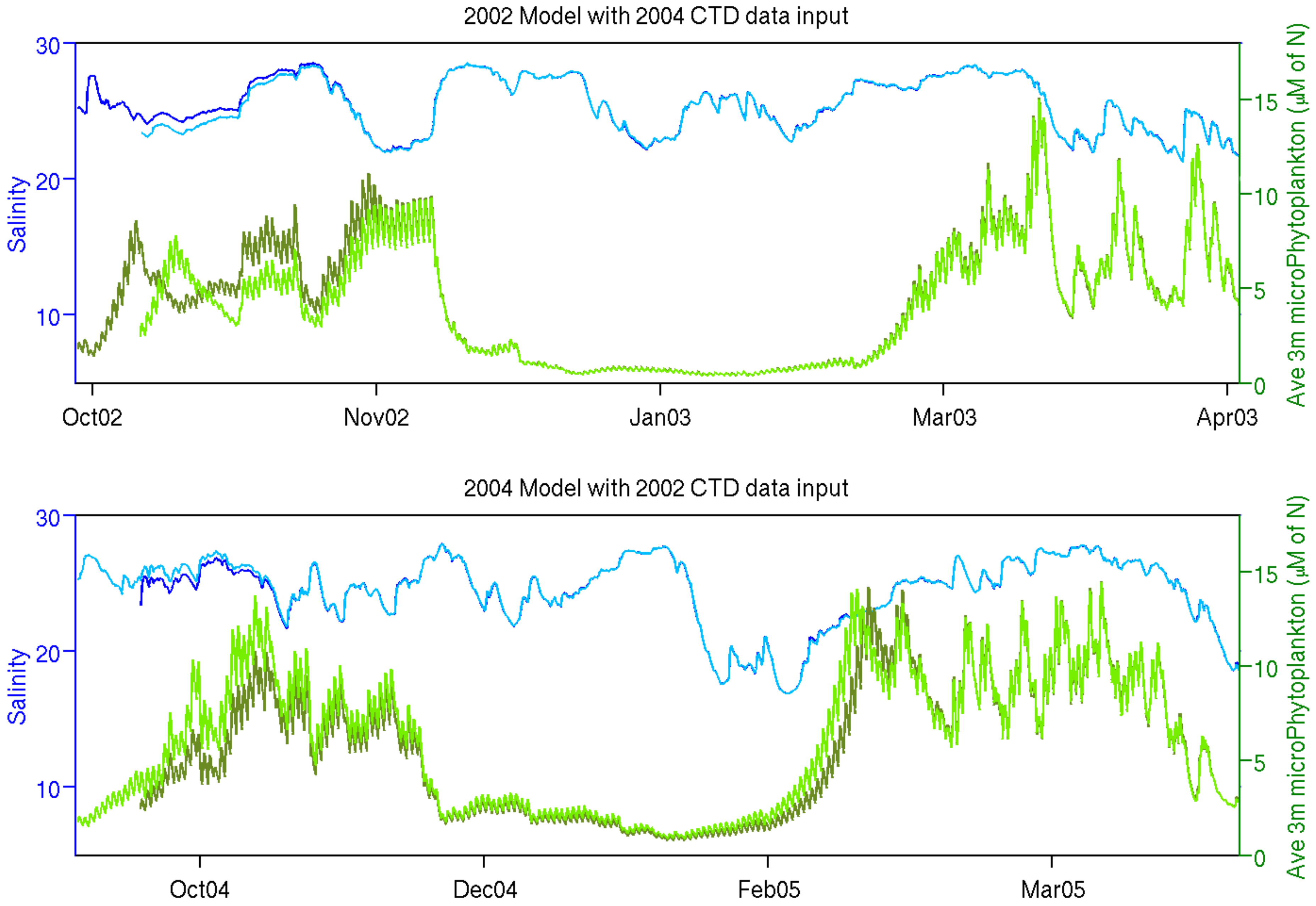
Weather and river data available back 30 years

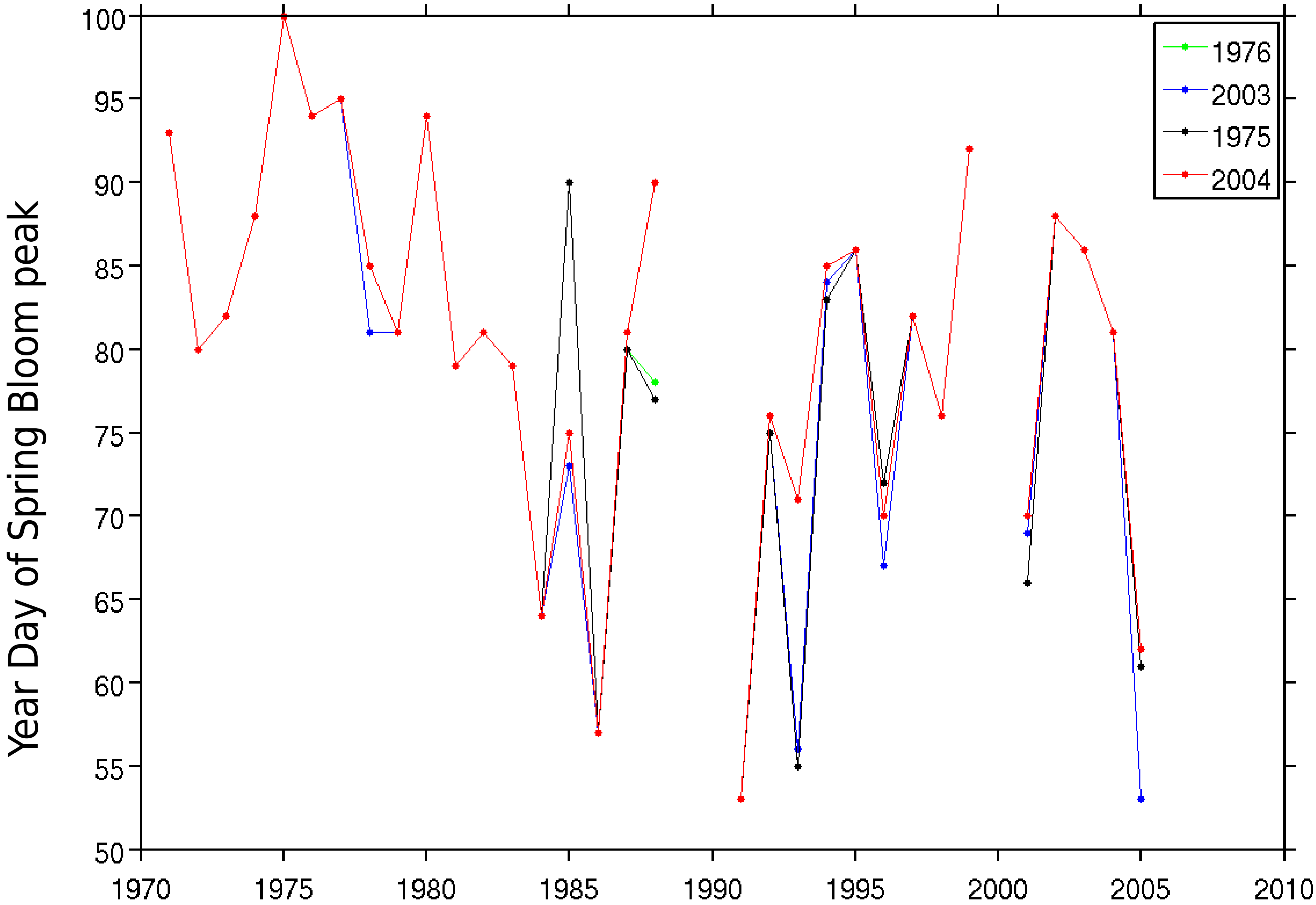
Deep water temp and salinity measured at Nanoose

Initial conditions are only sporatically available

Test code for sensitivity to initial conditions




2002 Model with 2004 CTD data input
Salinity
Ave 3m microPhytoplankton (μM of N)
30
20
10
15
10
5
0
Oct02
Nov02
Jan03
Mar03
Apr03
2004 Model with 2002 CTD data input
Salinity
Ave 3m microPhytoplankton (μM of N)
30
20
10
15
10
5
0
Oct04
Dec04
Feb05
Mar05



Year Day of Spring Bloom peak
100
95
90
85
80
75
70
65
60
55
50
1970
1975
1980
1985
1990
1995
2000
2005
2010
1976
2003
1975
2004

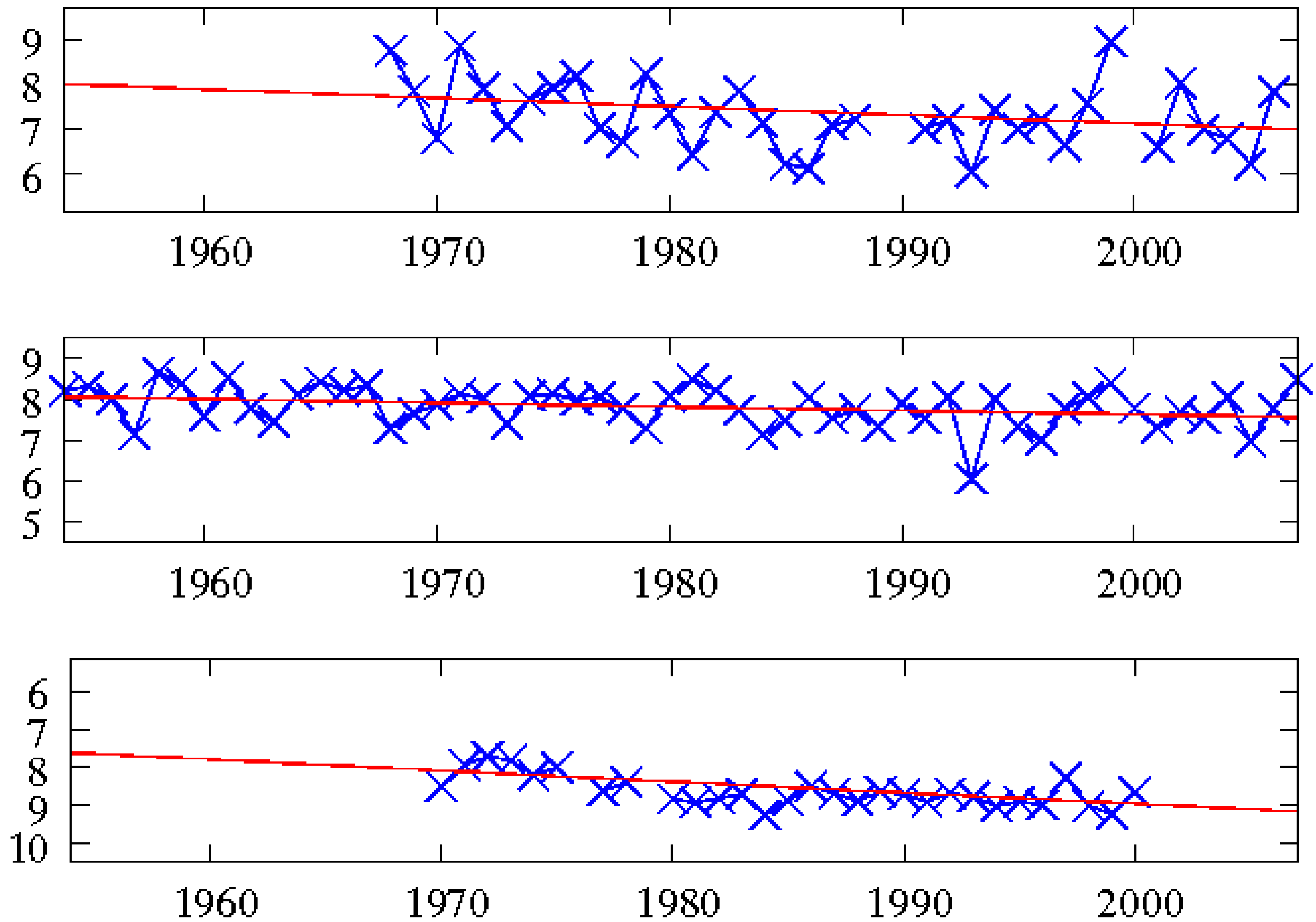
50 Years – Weather Changes

Average values for December - February

Wind (m/s)

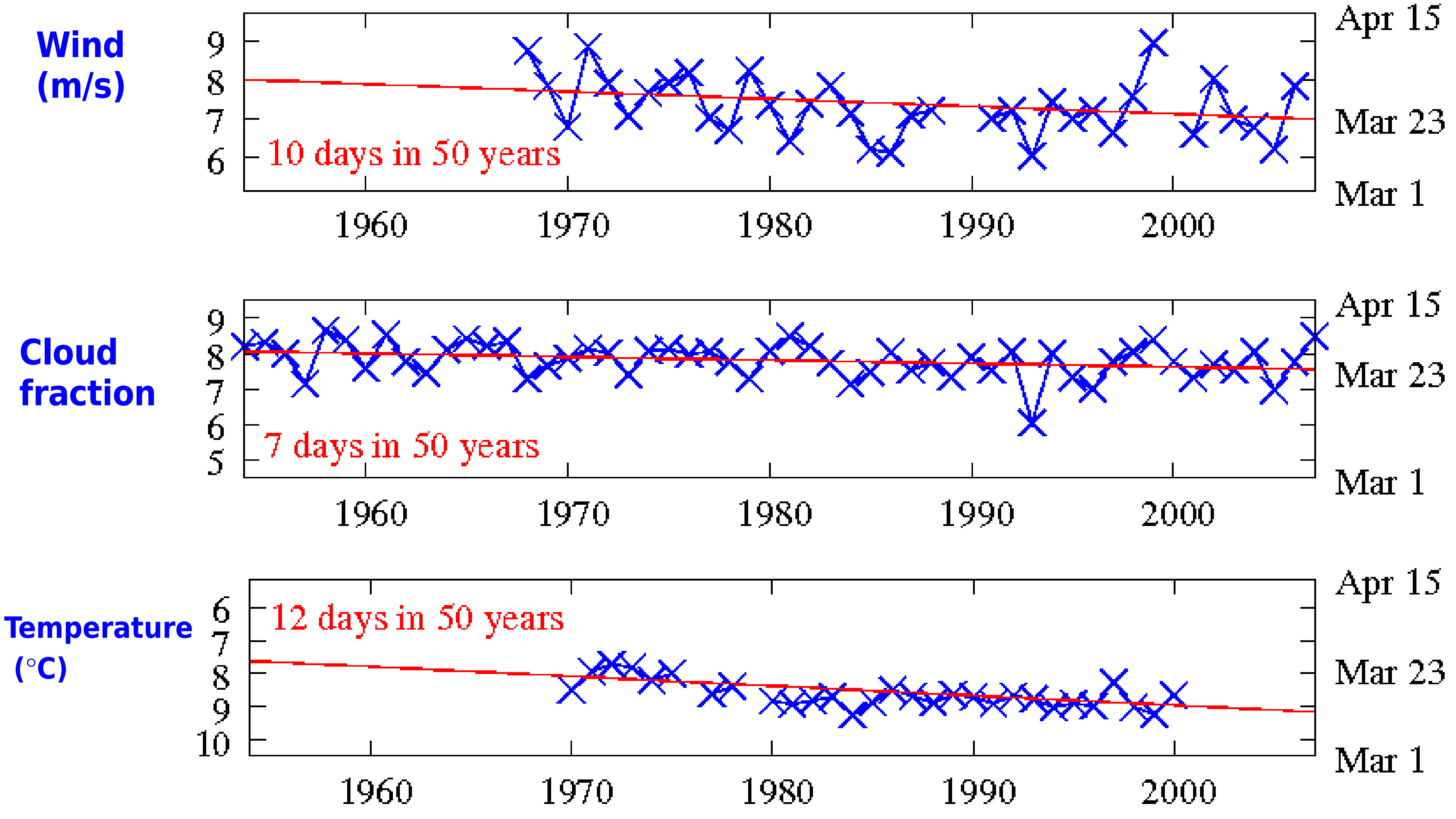
Cloud fraction

Temperature (°C)



50 Years – Weather Changes

Average values for December - February



The Future

Wind patterns are expected to strengthen and move northward. Leaves the Strait of Georgia in a region where winds should not change much

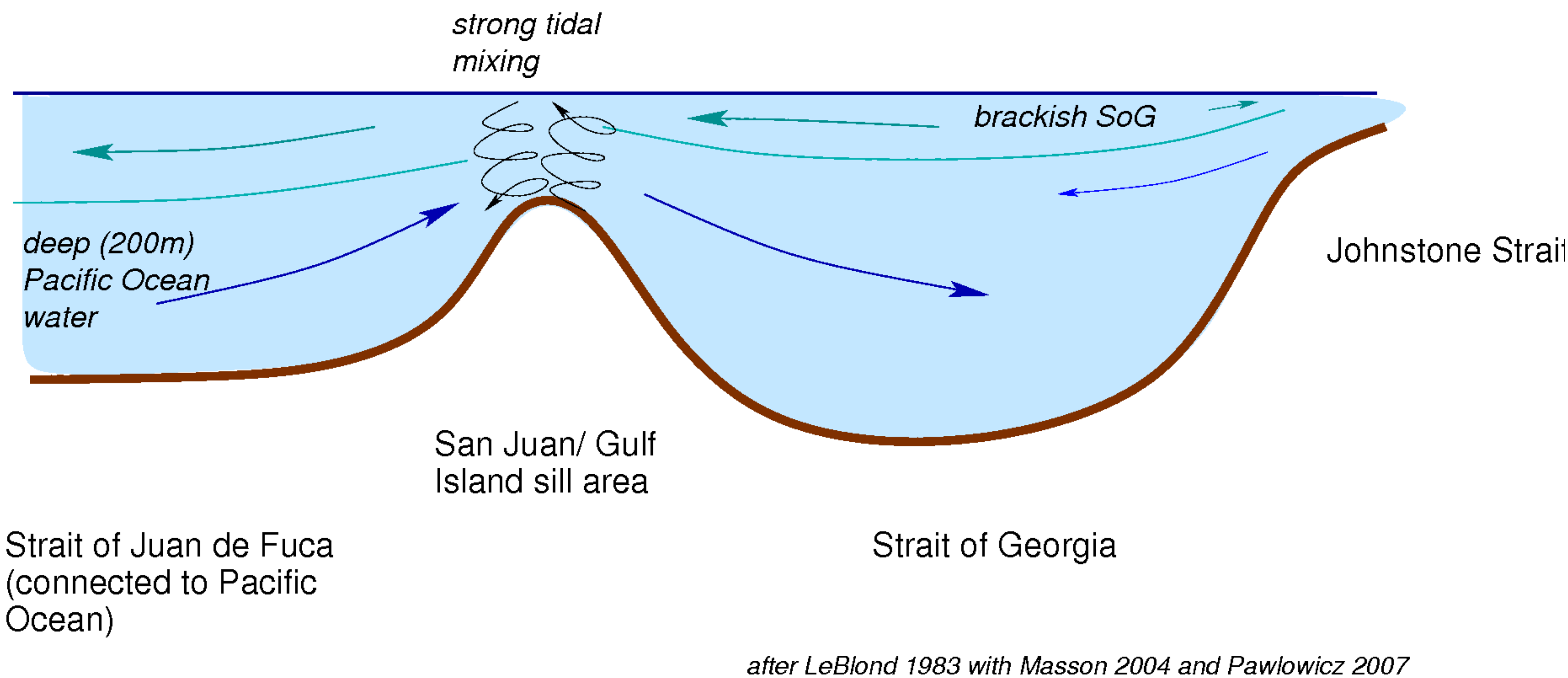
We should be further from the storm tracks so perhaps less cloud

It will continue to warm (air and water)

Spring Bloom will continue to advance in the year

Limitations 1 (physics)

No spatial information



Limitations: 2 (biology)

The model is based on (Thalassiosira sp.) If the spring bloom species changes this could significantly impact the spring bloom timing.

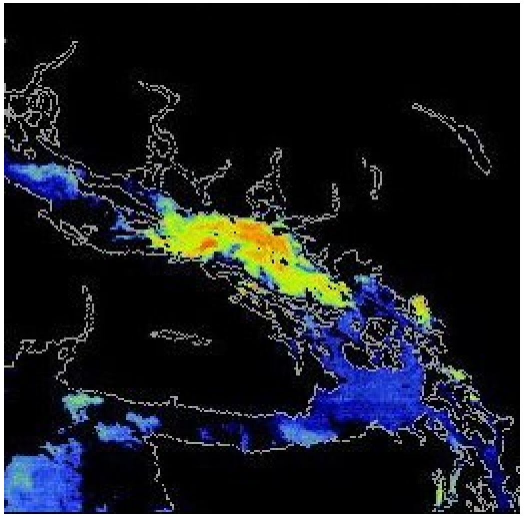
The model is sensitive to zooplankton grazing. Changes in winter grazing pressure would also impact the spring bloom

HOWEVER, as the four years were hindcast by tuning one-variable, these biological variations did not occur 2002-2005.

Comments on Model

Model was used to generate a regression which has been used to successfully predict the 2006, 2007, 2008 and 2009 spring blooms (within 7 days)

Given a specific question a simple model is often the appropriate choice.



Conclusions

The spring bloom in the SoG is primarily determined by the wind and secondarily by clouds and temperature

The spring bloom is relatively insenstive to freshwater flow

The spring bloom has moved earlier in the year over the last 30 years

Spring bloom is likely to continue to advance in the year