A Regional Climate Model for the British Columbia Continental Shelf

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Outline

- RCM details
- Historical evaluation
- Forcing fields
- Results to-date
- Summary & future work

Meris chlorophyll, Sept 11, 2011, courtesy Jim Gower & Erika Young
BC Shelf Model

Regional Ocean Modeling System (ROMS): Masson & Fain

- Model domain: south of Columbia River to the Alaska border
- Resolution:
  - Horizontal: 3km (236 X 410),
  - Vertical: 30 sigma levels
- Forcing:
  - tides,
  - 3 hourly wind and daily atmospheric forcing (NARR)
  - monthly discharge from 21 main rivers
  - monthly open boundary forcing (SODA)
- Hindcast:
  - 1995-2008
Over an annual cycle, the model behaves realistically:

1. SSTs show seasonal upwelling & downwelling

*Sea Surface Temperature (°C)*

**Climatology**

**ROMS (1997-2006)**
2. Annual cycle

Summer estuarine circulation in Salish Sea

ROMS - Summer

Observed - Summer

Fraser River
3. Interannual variability: (annual summer SST anomalies)

**AVHRR Pathfinder v5**

- 1997
- 1998
- 1999
- 2000
- 2001
- 2002
- 2003
- 2004
- 2005
- 2006

**ROMS**

- 1997
- 1998
- 1999
- 2000
- 2001
- 2002
- 2003
- 2004
- 2005
- 2006

°C
Future Forcing for the RCM

- Anomalies to 1995-2009 forcing & initial fields
  - Tides unchanged
  - Wind & heat flux thru interpolation from GCMs and/or RCMs
  - Oceanic initial conditions & boundary forcing from GCMs
  - Freshwater runoff by downscaling precipitation & temperature from RCMs

Projected Patterns of Precipitation Changes
North American Regional Climate Models

- 6 RCMs in North American Regional Climate Change Assessment Program (NARCCAP)
- 50 km resolution vs >1° for GCMs
- 1971-2000 & 2041-2070
- IPCC AR4 A2 scenario (business as usual)
- http://www.narccap.ucar.edu

Mean (1971-90) daily precipitation (mm) as computed by top): the CCCma GCM, bottom): the CRCM.
Freshwater Discharges affecting the BC Coast

- Freshwater discharges generate coastal currents which are important to marine ecosystems

- Total drainage basins $\approx 1,315,000$ km$^2$ but $\approx 20\%$ is ungauged

- Morrison et al (2011) developed technique to estimate ungauged runoff using precipitation, terrain, storage capacity etc. within 22 watersheds
  - Verified vs observations
  - Re-constructed total discharge time series back to 1970 (no trends)
  - Applied to future discharges using RCM precipitation & temperatures
Contemporary & Future Freshwater Discharges

- **Estimated from NARCCAP CRCM/CGCM3 precipitation & snowcover output**
- **Except for June-Aug, more runoff in future**

**Salish Sea Freshwater Discharge**

CRCM-CGCM3 Snowcover and Precipitation

**Coastal Freshwater Discharge**

CRCM-CGCM3 Snowcover and Precipitation
Heat Flux Forcing

- **CRCM grid is too coarse**
  - coastal regions defined as land
  - affects heat flux variables

- **CRCM data was downsampled into coastal regions using EOFs**
  - patterns generated from SODA re-analysis output
  - *Special treatment in Salish Sea*
    - coastal data could not be reliably predicted from offshore data
    - assigned average of the values at either end of the straits
Air temperature anomaly is \(~1.5-2^\circ\text{C}\), increasing with latitude.

Precipitation anomaly is greatest in winter, almost non-existent in summer.

Seasonal cycle dominates anomaly.

Precipitation anomaly \(> 0\) (6\(\times\)10\(^{-6}\) \(~0.5\text{mm/day}\))

For now, just spatially varying anomaly fields; seasonally next.
Initial and Boundary Conditions

- **3D TS anomalies from CGCM3 (no active ocean in CRCM)**
  - Future will be warmer and fresher

- Anomaly was averaged over constant latitude and then applied to the current initial and boundary conditions

- Greatest anomaly at the surface & at high latitudes

- Max temp anomaly not at surface - deepening of the thermocline
14 year simulation: SSTs

- Future forcing has only heat flux & initial/boundary anomalies
  - Winds & freshwater discharges unchanged
Temperatures in the Salish Sea

SST anomaly greatest in Georgia Strait, least in areas and times of greatest mixing and times of river influence. Normal seasonal variability is between 8 and 12 degrees at the surface.
Summary

- development & preliminary results from BC shelf, ocean-only, RCM
  - ROMS with 3km resolution
  - Future forcing & initial field anomalies computed from NARCCAP CRCM/CGCM fields
  - Incremental build-up of future forcing
    - Results so far with only future initial TS & heat flux fields

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Future Work

- Future winds & freshwater discharge runs soon
- Ensemble with other NARCCAP RCM output
- Couple to NPZD & geochemical ecosystem models

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