Global warming – modeling effects on agriculture in the Okanagan

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Global warming and climate change

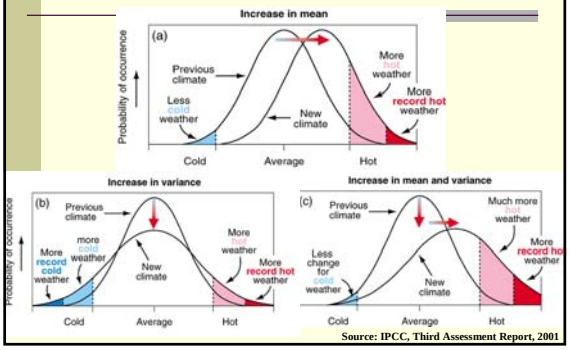
IPCC –Assessment report 4 (AR4)

Phenomona and direction of trend	Likelihood	Agriculture, forestry and ecosystems	Water resources
Warmer and fewer cold days and nights Warmer and more frequent hot days and nights	Virtually certain	Increased yields in colder environments; decreased yields in Warmer environments; Increased insect outbreaks	Adverse effects on water resources relying on snow melt;
Warm spells/heat waves. Frequency increases over most land areas	Very likely	Reduced yields in warmer regions due to heat stress; Wild fire danger increase	Increased water demand; Water quality problems, e.g. algal blooms
Heavy precip. events. Frequency increases over most areas	Very likely	Damage to crops; soil erosion, Inability to cultivate land due to water logging of soils	Adverse effects on quality of surface & groundwater; Contamination of water supply; Water scarcity may be relieved

IPCC –Assessment report 4 (AR4)

Phenomona and direction of trend	Likelihood	Agriculture, forestry and ecosystems	Water resources
Area affected by drought increases	Likely	Land degradation, Lower yields/crop Damage and failure; Increased livestock deaths; Increased risk of wildfire	More widespread water stress
Intense tropical cyclone activity increases	Likely	Damage to crops; Windthrow (uprooting) of trees; Damage to coral reefs	Power outages cause disruption of public water supply
Increased incidence of extreme high sea level (excludes tsunamis)	Likely	Salinisation of irrigation water, estuaries and freshwater systems	Decreased freshwater availability due to saltwater intrusion

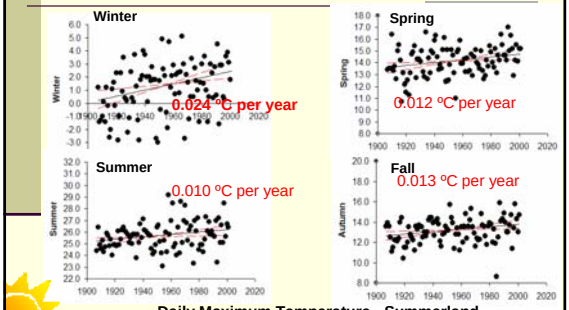
How climate may change in the future



Source: IPCC, Third Assessment Report, 2001

Recent climate trends and some consequences

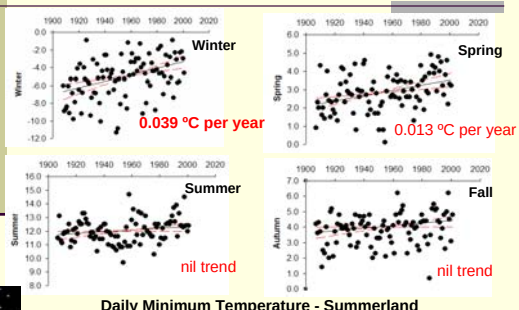
Okanagan -Trends in Daily Maximum Temperature (1916-2000)



Daily Maximum Temperature - Summerland

Source: Bill Taylor and Mark Barton -Environment Canada -PYR

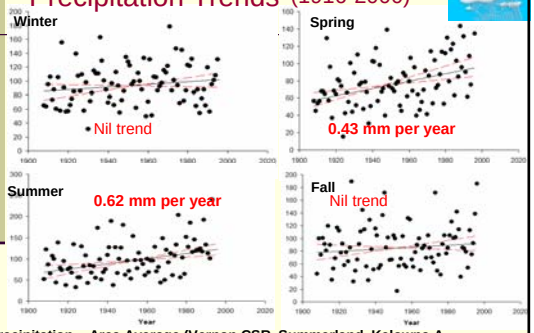
Okanagan -Trends in Daily Minimum Temperature (1916-2000)



Daily Minimum Temperature - Summerland

Source: Bill Taylor and Mark Barton -Environment Canada -PYR

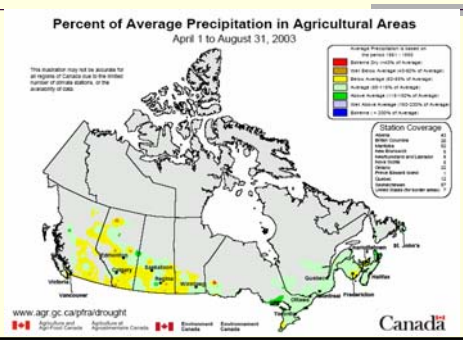
Precipitation Trends (1916-2000)



Precipitation – Area Average (Vernon CSR, Summerland, Kelowna A, Penticton A)

Source: Bill Taylor and Mark Barton -Environment Canada -PYR

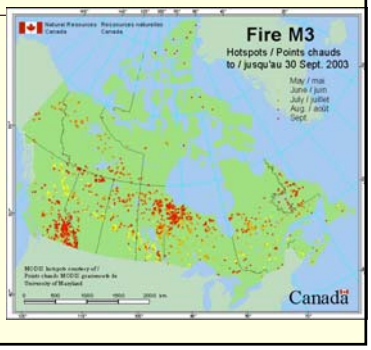
The Drought of 2003



Fires of 2003

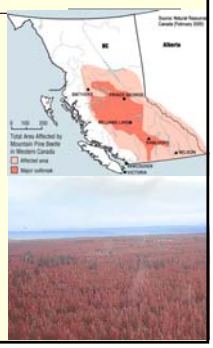
Okanagan Mountain Park Fire

Okanagan-Urban Wildland Interface



Mountain Pine Beetle

- a landscape with an abundance of susceptible trees
- sustained favourable weather
- a lack of effective control action during the outbreak's incipient stage.
- The major outbreak present for approximately 10 years
- infestation has increased rapidly in recent years to become the largest in the province's history.
- A winter low of -40°C or a sudden cold snap in early fall or late spring of -25°C would reduce beetle populations enough to end the outbreak.



Global climate models for future climate scenarios

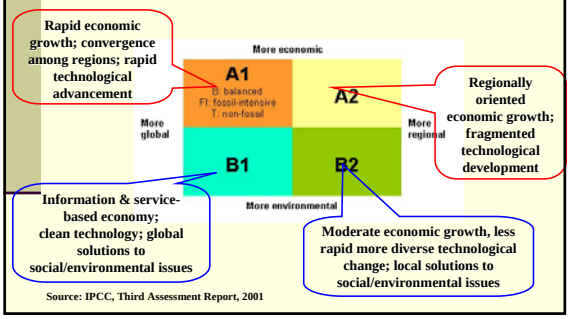
Projections of global temperature change (**G**lobal **C**limate **M**odels)

- **Based on complex, physically based simulations of the earth's atmospheric and ocean circulation patterns**
- **Modified by different greenhouse gas emissions scenarios**

Uncertainties with GCMs

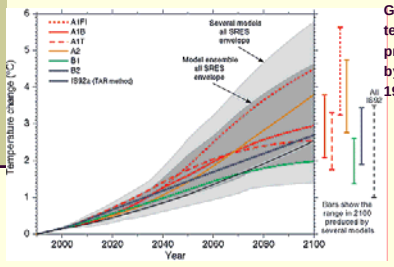
- **Differences associated with modeling procedures (many different models available)**
- **Differences associated greenhouse gas emissions scenarios**
- **Scale at which information is available**

SRES Scenario Family - six marker scenarios



Source: IPCC, Third Assessment Report, 2001

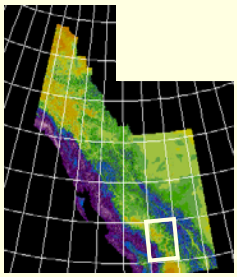
Global temperature response to SRES scenarios



Global average temperature is projected to increase by 2.5 to 10.4°F from 1990 to 2100

Source: IPCC, Third Assessment Report, 2001

Creating climate scenarios



- **Resolution of CGCM2**
  - **3.7° lat. x 3.7° long.**
  - **400km x 250km at mid-latitudes**
- **Needs to be downscaled to meet regional requirements**

Downscaling to weather stations – previous study

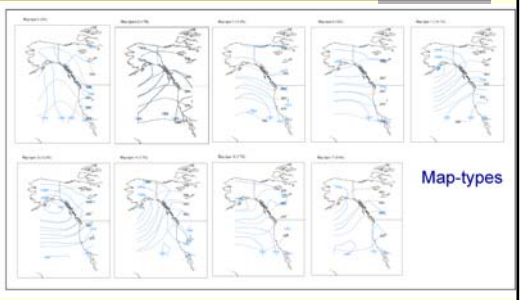
GCM-adjusted baseline (delta method)

- Apply to *daily* station data:
  - add changes in temperature
  - multiply by changes in precipitation(%)

Downscaling using weather patterns -new study

- **Synoptic map typing**
  - **GCMs model circulation patterns better than climate variables**
  - **Major circulation patterns can be classified according to synoptic maps and linked to climate/weather events of interest**
  - **Can also use 'delta' method to relate to GCM estimates of increased global temperature**

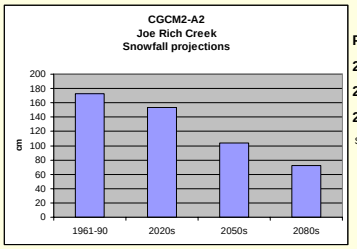
Okanagan- dominant map types



Downscaling- synoptic map typing

Map type	Circulation Pattern	Upper Air feature	Cold/ warm	Wet/dry	Season
4	Arctic outflow	Pacific Ridge	Very cold	-	Winter
5	Northwest flow	Weak ridge to west	Cool	-	All
7	Cyclonic	Weak trough	Cool	-	All
8	Zonal/ Unstable	Weak ridge	-	-	All
11	Anticyclonic	Off-shore trough	Warm	-	Winter
12	Moist South-West flow	Strong ridge coast	Warm	Wet	Winter
14	Idaho High	Off-shore trough	-	Dry	Fall-Winter
16	Convective	Blocking High	Warm	-	Summer
17	Stagnant		Very hot	Dry	Summer

Okanagan map-typing – snow



Percent Change

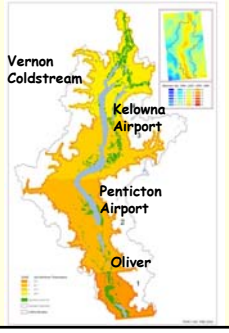
2020s 11% reduction

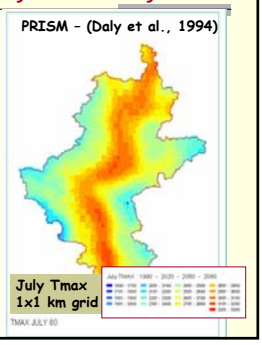
2050s 40% reduction

2080s 58% reduction

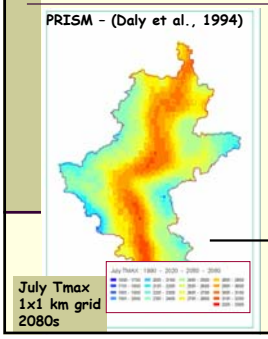
Source: Bill Taylor (ECB)

Spatial distribution of climate data in relation to topography- old study

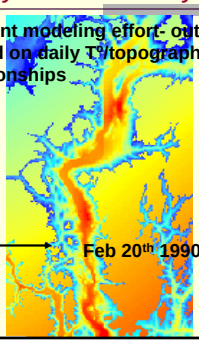




Spatial distribution of climate data in relation to topography- current study



Current modeling effort- output based on daily T°/topography relationships

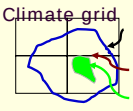


Approach to water demand modeling

Crop water demand modeled based on:

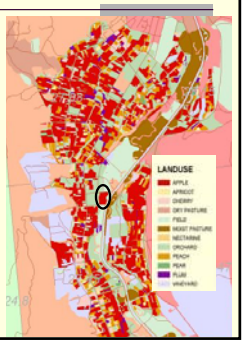
- Gridded climate data
- 18 GCM/SRES/time slice scenarios
- Mapped land use
  - **Each parcel geo-referenced**
- Estimates of ET (climate based) modified by canopy development factors, growing season length (based on GDD)

Model Structure –old project

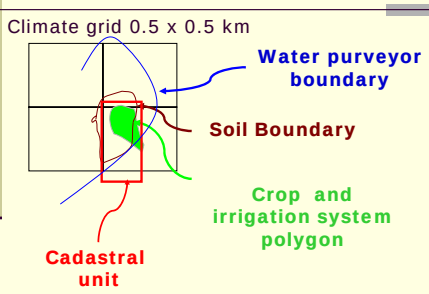


Accumulation of crop water use

1. Crop polygon
   - water use x polygon area
2. Sub-watershed
   - Sum of crop polygons
3. Water Purveyor
   - Sum of crop polygons
4. Basin
   - Sum of crop polygons



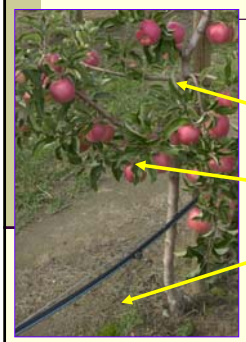
Model Structure – current project



Model relating climate to crop water demand

- **Estimate of potential evapo-transpiration based on daily max.temperature and solar radiation (new project better methodology)**
- **Estimate of actual evapo-transpiration from crop-coefficient curves**
- **Estimate of length of growing season based on time of bloom (fruit trees) and growing degree day accumulation (other crops)**

Crop water demand



Solar radiation

Wind

Transpiration from leaf stomates

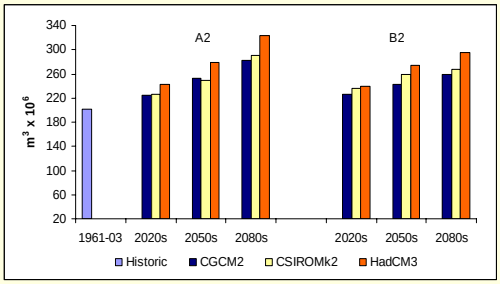
Evaporation from the leaf surface

Evaporation from the soil surface

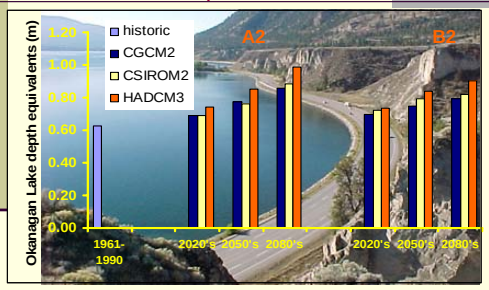
Increases as **plant canopy** grows (seasonal, year to year)

Okanagan Basin Results
30 year averages

Average Okanagan Basin crop water use in response to climate change

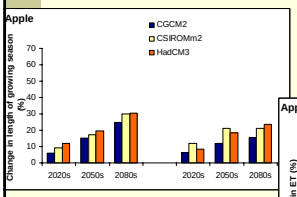


Depth of water required from Okanagan Lake to meet basin crop water demand

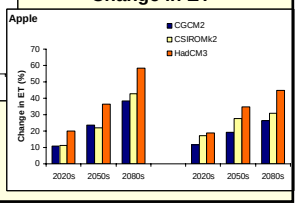


Change in growing season and ET on average

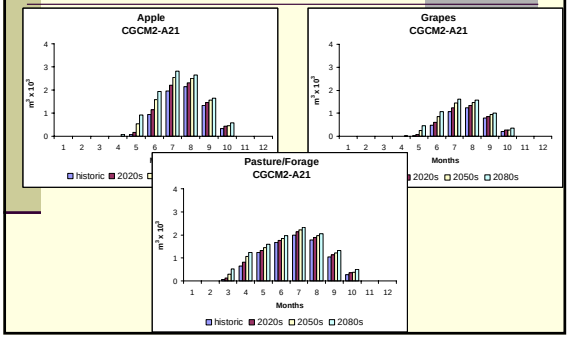
Change in length of growing season

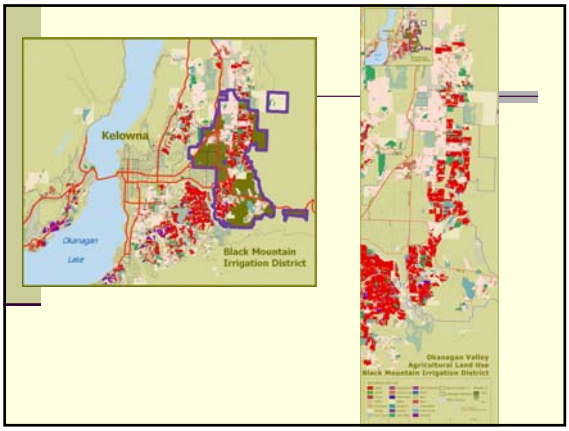


Change in ET

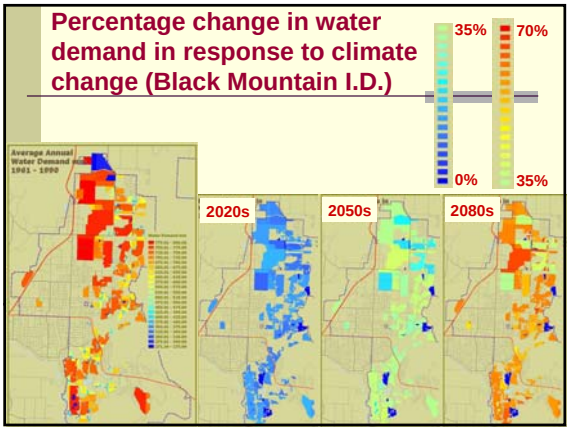


Average water use in response to climate change – crop

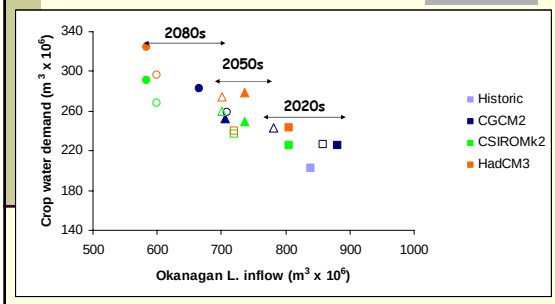




Percentage change in water demand in response to climate change (Black Mountain I.D.)



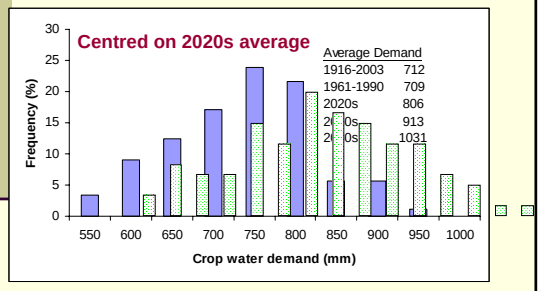
Average basin water supply/demand response to climate change



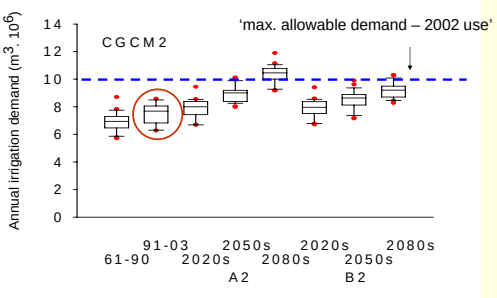
Supply –UBC watershed model (Merrit and Alila)

Okanagan Basin Results
Yearly data

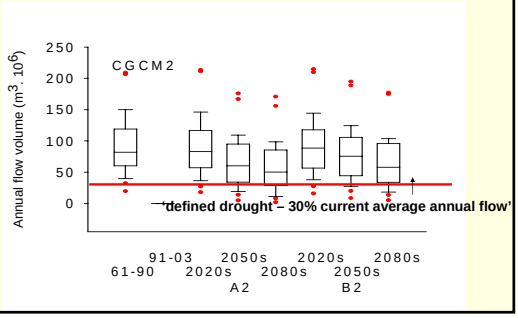
Historic variation in crop water demand at Summerland



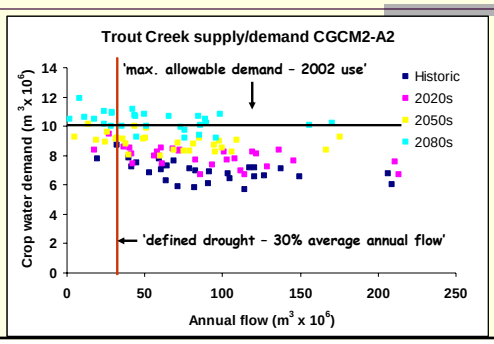
Annual variation in crop water demand for District of Summerland 1961-2100



Annual variation in water supply (Trout Creek annual flow-UBC watershed model)



Variation in crop water demand and Trout Creek flows in response to climate change



Approach to water demand modeling

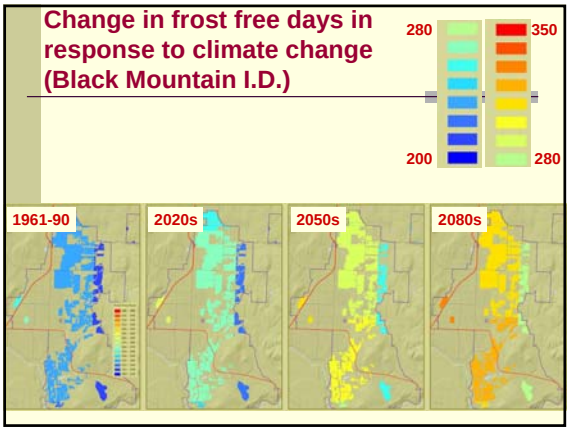
Current project

- **Improved climate downscaling and spatial interpolation**
- **Improved estimates of ET**
- **Soil and landscape limitations included**
- **Irrigation system (when applicable)**
- **Improved definition of growing season**
- **Improved land use data**
- **More crop types defined**

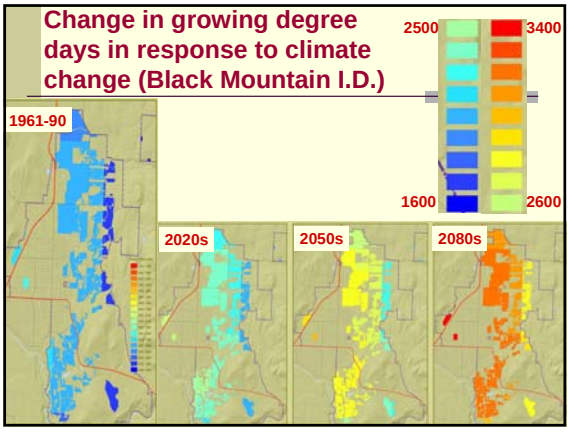
Opportunities associated with climate change

- **Longer growing season**
  - multiple crops
  - higher yielding varieties (e.g. corn)
- **Warmer growing season**
  - new crops
  - improved quality of some crops (premium wines)
- **Warmer winters**
  - new perennial crops

Change in frost free days in response to climate change (Black Mountain I.D.)



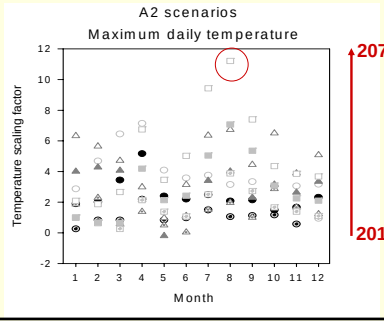
Change in growing degree days in response to climate change (Black Mountain I.D.)



Risks associated with climate change

- **Longer growing season**
  - More generations of insect pests
  - Earlier and later demand for water
- **Warmer growing season**
  - new pests, diseases
  - Reduced quality of some crops (apples)
- **Warmer winters**
  - Pests and diseases over-winter
  - Freshet earlier; earlier demand for stored water
- **Food imports adversely affected**
  - insufficient capacity to respond

Daily maximum temperature increases in the Okanagan Basin for a range of climate change scenarios



Future studies

- Coupled hydrology, storage and demand models to determine critical events e.g. timing of first withdrawals from reservoir storage
- Analysis of severity and frequency of extreme events (droughts, storms etc.)
- Improved models of crop suitability

Thank you