



Water Resources Vulnerability and Adaptation to Climate Change

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Outline of today's talk...

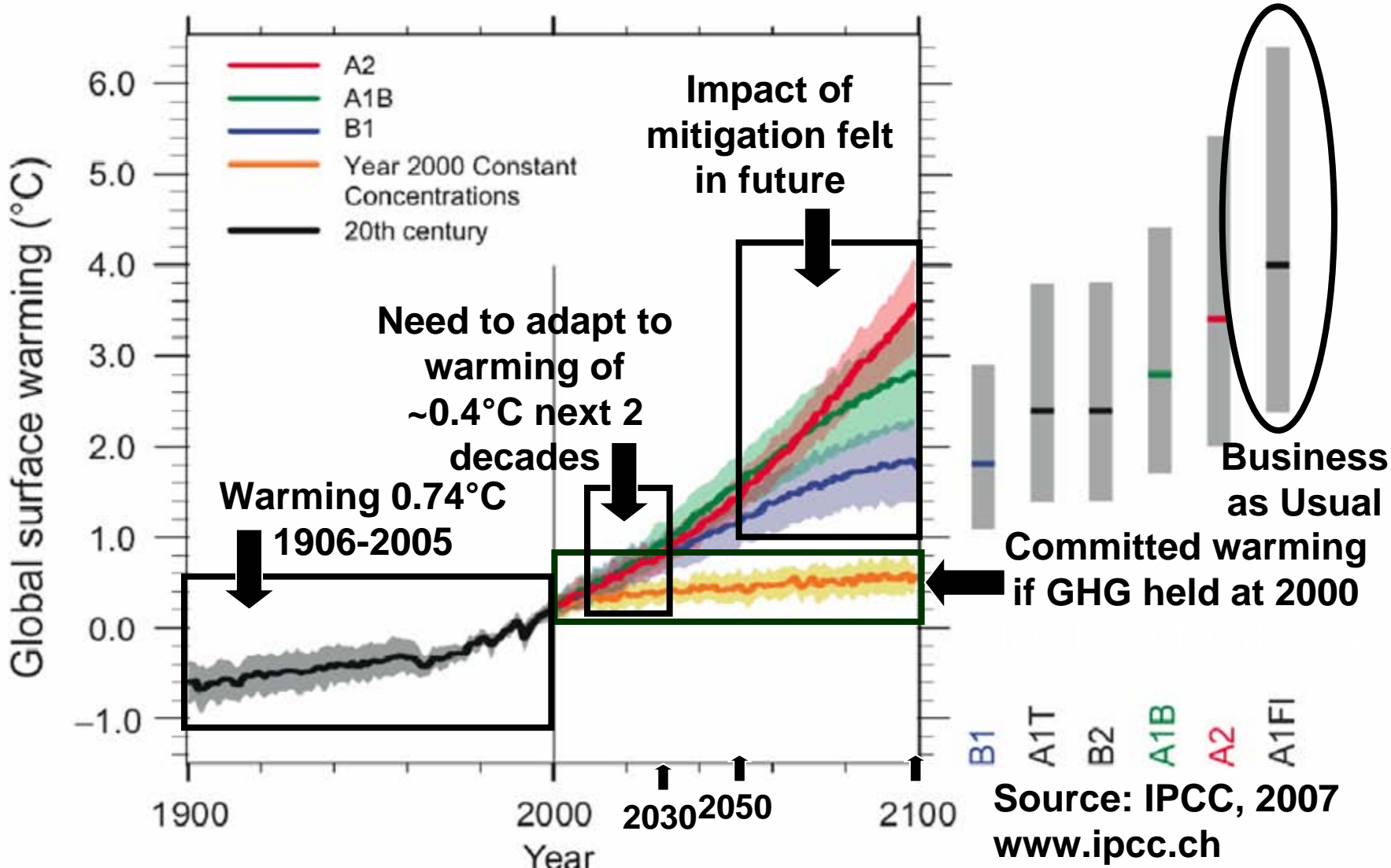
- What does climate change mean for the Great Lakes Basin?
 - Climate scenarios
 - Hydrology
 - Ecosystems



“Warming of the climate system is unequivocal...” IPCC 2007

- Global annual temperature +0.74°C – 1906 to 2005
- Detecting changes in natural systems: snow, ice, & phenology
- Warming by 2100:
 - globally 1.8°C to 4.0°C depends on emission scenarios (best estimates)

We need to adapt (and mitigate)...



Balanced response to climate change...

- **Mitigation** – reduce emissions & increase sinks of greenhouse gases to halt/prevent climate change
 - change light bulbs, cap & trade program to new energy strategy
- **Adaptation** – respond to impacts of changing climate - moderate harm or exploit beneficial opportunities
 - water conservation to integrated water strategy

Projected changes in climate for the Great Lakes Basin (✓ observed)

Airshed Effects:

- ✓ Increase in air temperatures
- ✓ Increase in precipitable water in warmer atmosphere
- Change in frequency and intensity of storms



Nearshore Effects:

- ✓ Increase in water temperature
- Increase in evaporation

Inlake Effects:

- ✓ Increase in water temperature
- Higher evaporative losses from lakes
- ✓ Less ice cover (shorter duration)

Watershed Effects:

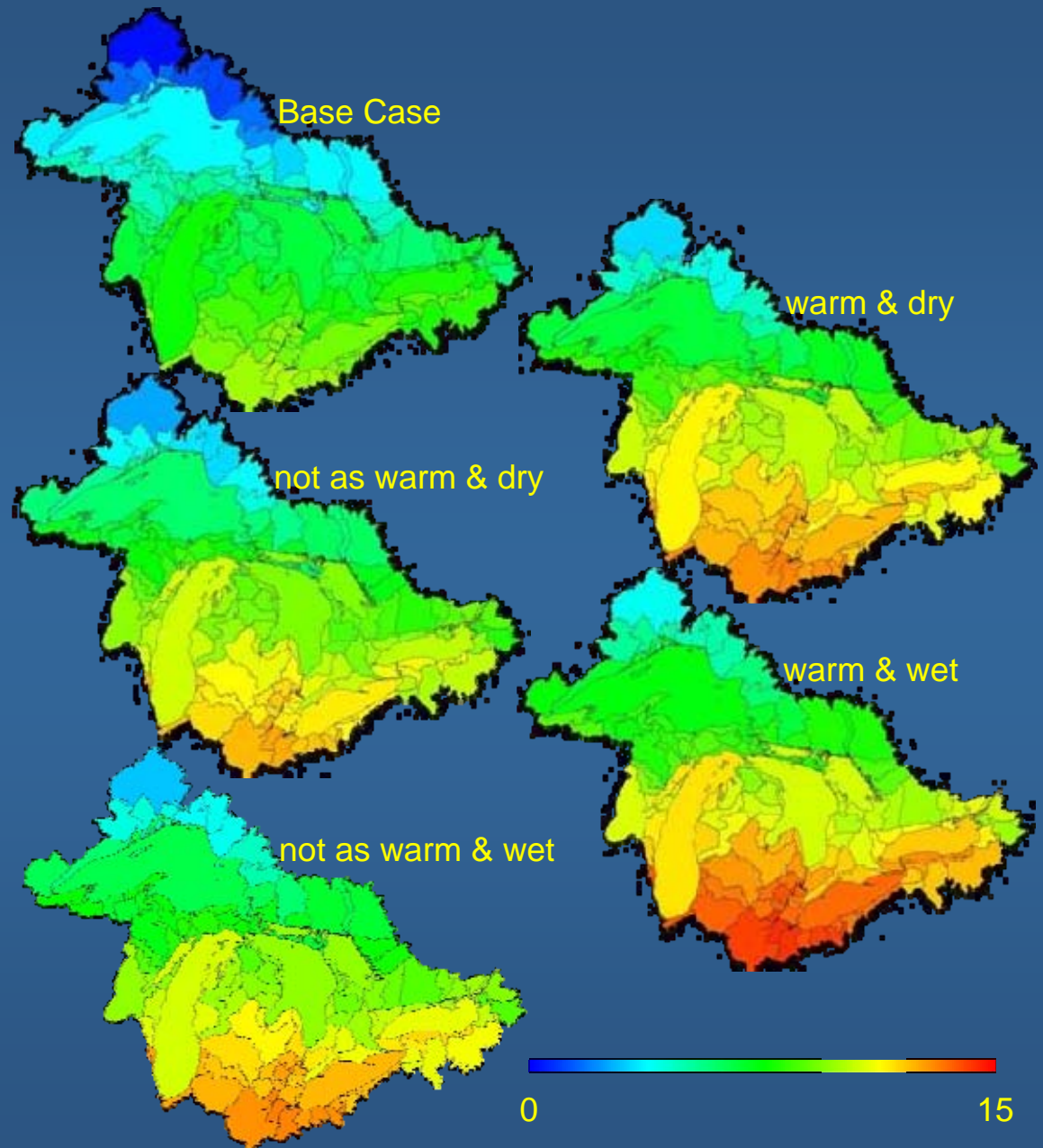
- ✓ Warmer air temperatures
- More precipitation (decreases in key seasons)
- ✓ Less winter precipitation as snowfall and more rain
- ✓ Less snowpack
- ✓ More intense precipitation events
- Increase in evapotranspiration

Great Lakes Basin Climate Change Scenarios: temperature (T-°C) & precipitation change (P-%) for 2050s relative to 1961-1990

| GCM | | ANNUAL | WINTER (DJF) | SPRING (MAM) | SUMMER (JJA) | FALL (SON) |
|---|---|--------|-----------------|-----------------|-----------------|---------------|
| HadCM3 A1FI Warm & Wet | T | +3.99 | +3.09 | +3.57 | +4.44 | +4.07 |
| | P | +10.33 | +21.52 | +19.18 | +3.06 | +4.67 |
| CGCM2 A21 Warm & Dry | T | +3.24 | +4.32 | +3.26 | +3.17 | +2.21 |
| | P | +1.40 | +4.38 | +4.39 | -1.60 | +1.28 |
| HadCM3 B22 Not so Warm & Wet | T | +2.84 | +3.33 | +2.35 | +3.08 | +2.60 |
| | P | +12.51 | +20.81 | +19.93 | +7.70 | +8.00 |
| CGCM2 B23 Not so Warm & Dry | T | +2.24 | +3.17 | +2.57 | +2.32 | +1.60 |
| | P | +2.84 | +5.33 | +6.60 | +0.10 | +1.35 |

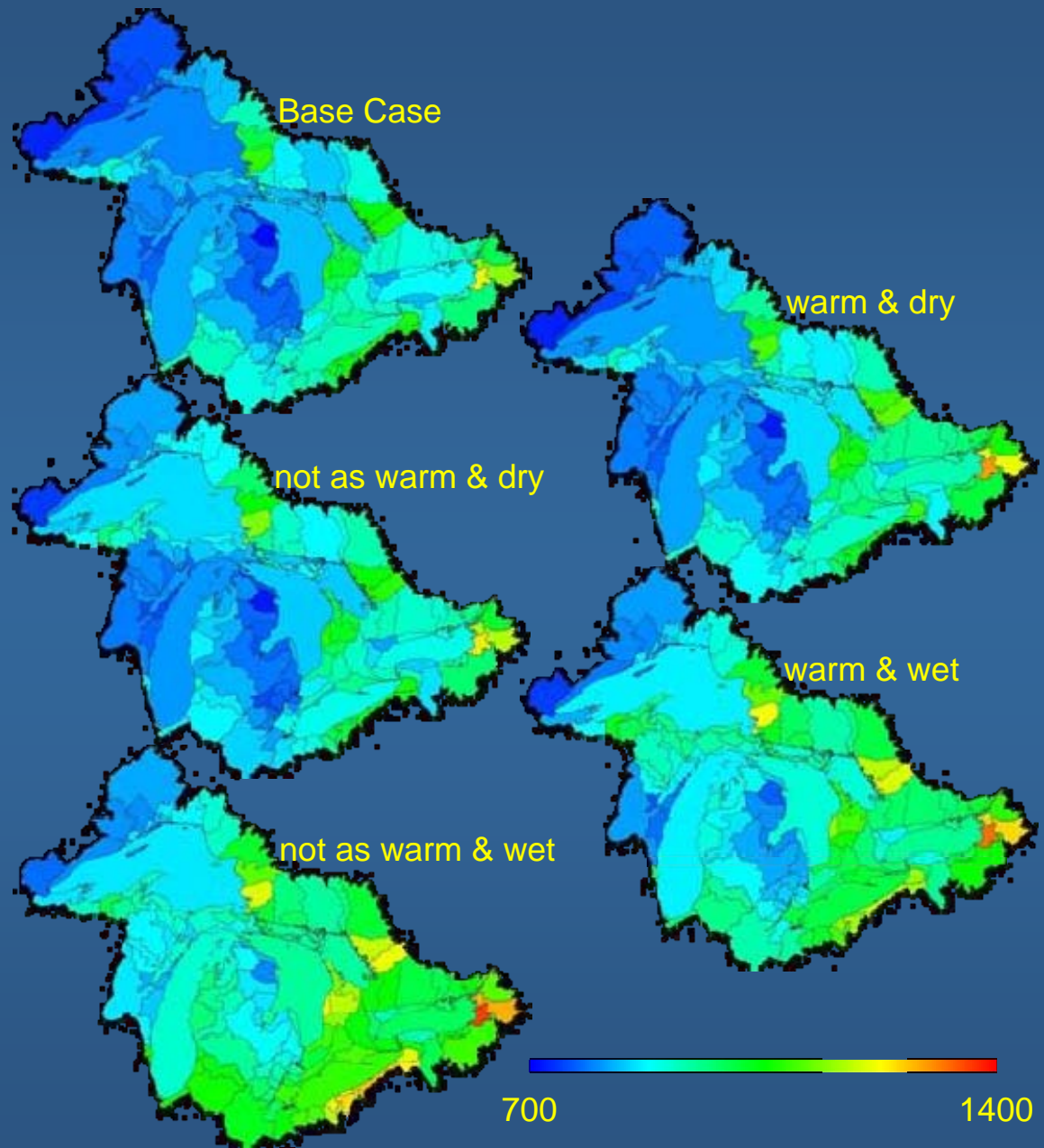
Annual average air temperature (°C)
Base case & 2050s

Source: Croley, GLERL



Annual total
precipitation (mm)
Base case & 2050s

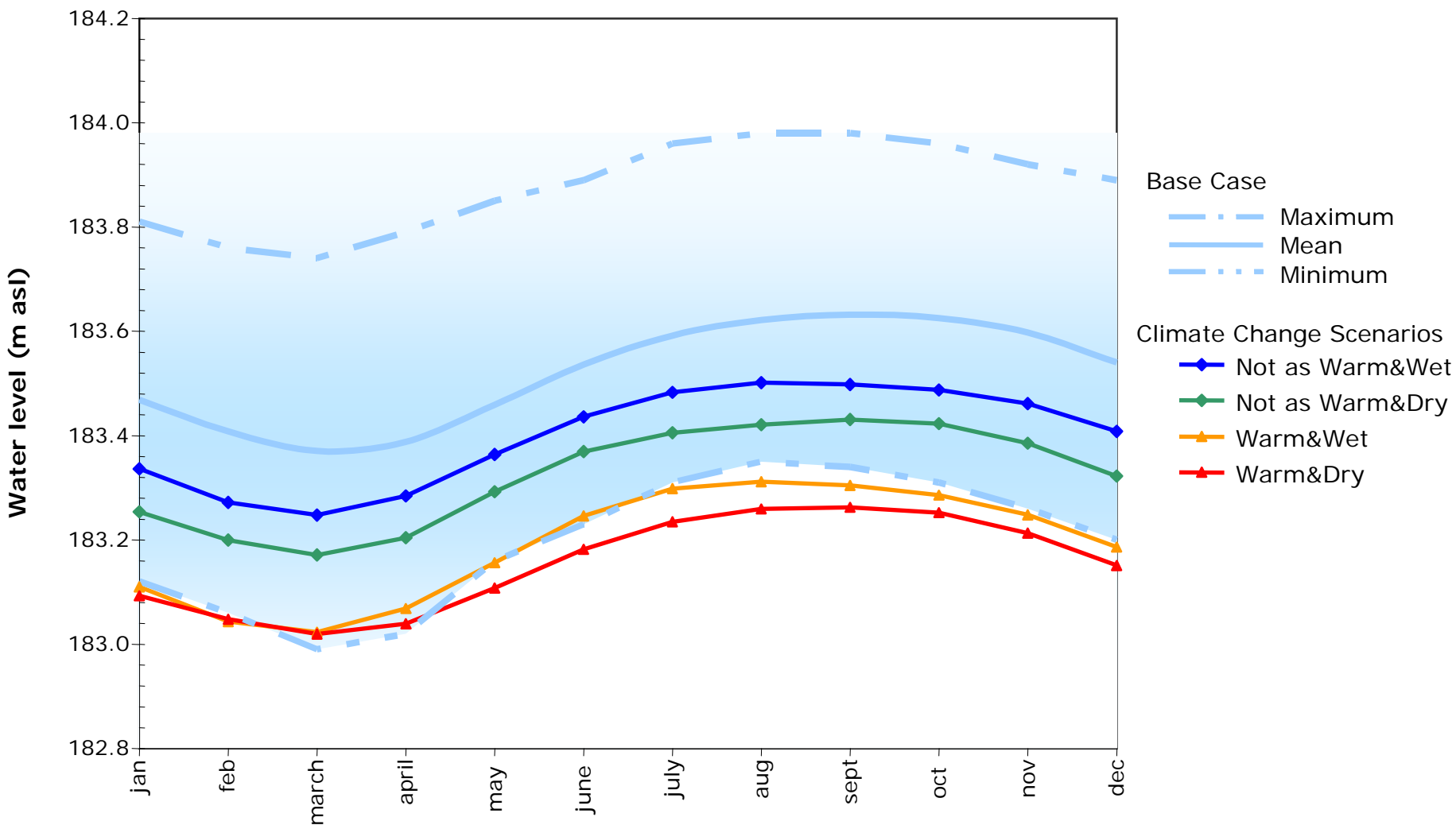
Source: Croley, GLERL



Lake Superior – Hydrologic impacts, 2050s

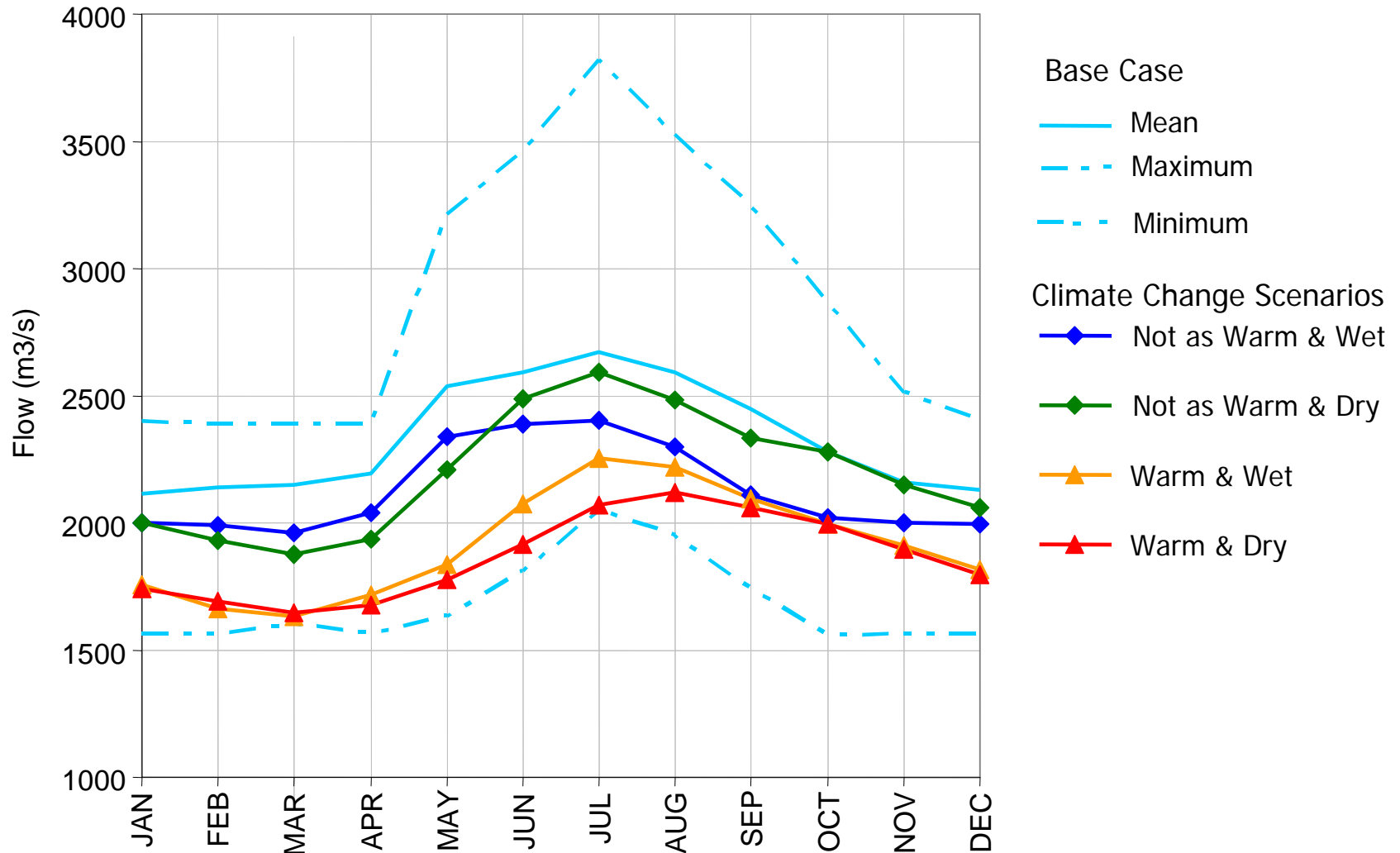
| | BASE CASE | WARM & DRY | NOT-AS WARM & DRY | WARM & WET | NOT-AS WARM & WET |
|--|-------------|-----------------------|----------------------|-----------------------|----------------------|
| LAKE OUTFLOW STATISTICS (m³/s) | | | | | |
| Annual Mean | 2334 | 1865 (-20%) | 2194 (-6%) | 1914 (-18%) | 2128 (-9%) |
| CHANGE OF LAKE LEVEL FROM BASE CASE (cm) | | | | | |
| Annual | | -36 | -20 | -33 | -12 |
| Winter | | -38 | -21 | -36 | -13 |
| Spring | | -35 | -18 | -32 | -11 |
| Summer | | -36 | -18 | -30 | -11 |
| Autumn | | -38 | -21 | -34 | -14 |

Lake Superior - Water Level Scenarios, 2050s

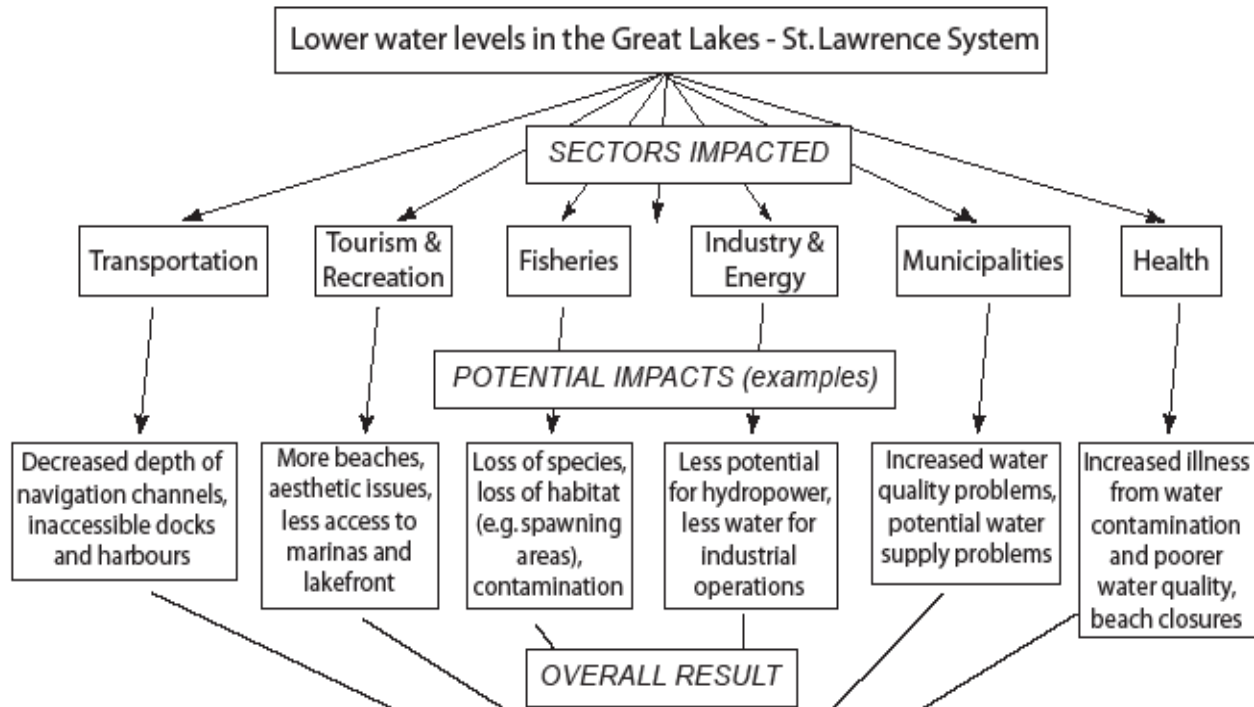


Source: Fay & Fan, Environment Canada

Lake Superior - Outflow Scenarios, 2050s



Water level decline has many multi-dimensional, interacting effects...



New flooding risks and potential increase in damages ...

- More intense precipitation and winter rain
 - flooding in winter and summer?
- Infrastructure must accommodate higher flows
 - safety and performance issues
- Re-evaluate floodplain management and emergency preparedness
 - more structures and people exposed



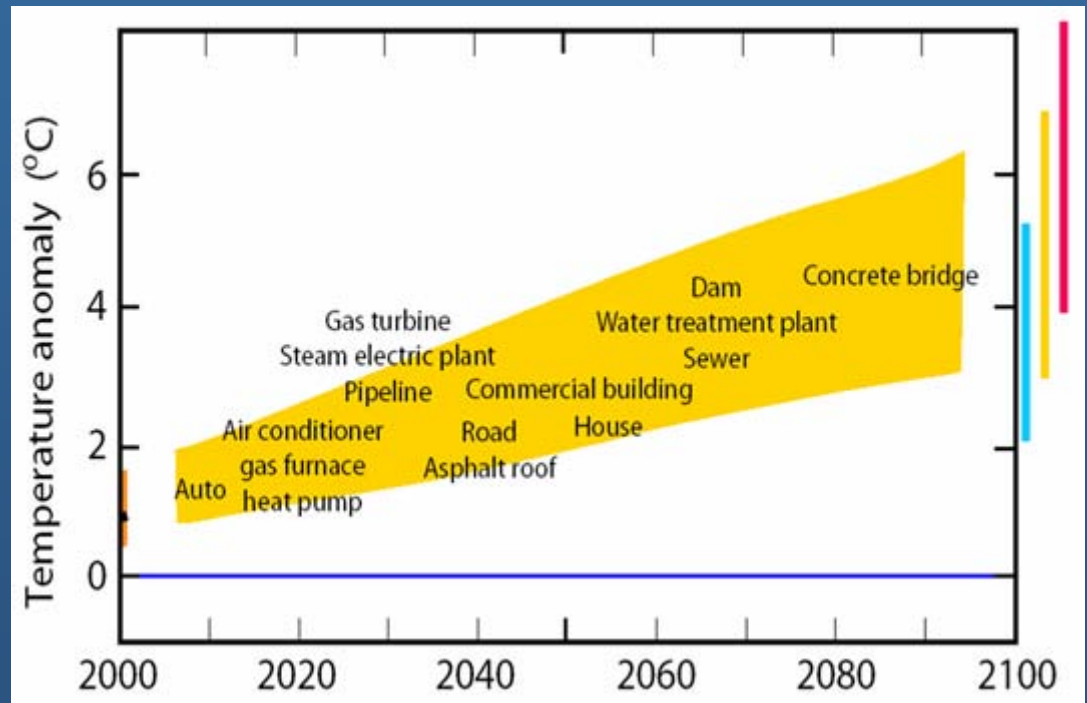
Changes in fish & wildlife populations ...

- Temperature and precipitation thresholds change
 - Ranges expand north e.g., L. Superior and zebra mussel?
- Poorer water quality – e.g., water temperature & dissolved oxygen
- Changes in food sources (or timing of availability)
- Rare & endangered, endemic & migrating species vulnerable



Infrastructure design needs to incorporate climate change ...

- Long life & high value of North American capital stock
- Avoid costly retrofits or underperformance of infrastructure



Climate change is a challenge and an opportunity ...

- Climate is changing
 - Past climate no longer reliable guide to the future
- Many projected impacts more extreme versions of what already experiencing locally
 - Exacerbate local management concerns and affect policy and programs
- How can we “mainstream” climate change information into decision-making?
 - Planning informed/guided by climate scenarios & monitoring
 - “No regrets” adaptations

Overcoming barriers ...

- **We'll deal with climate change when we see it happening**
 - many impacts of climate change are being observed
 - what are the climate trends in your local area
- **We'll deal with climate change when you tell us exactly what we need to plan for**
 - challenge of planning with evolving and imperfect information
 - what is the climate sensitivity of your activity/ sector/community
 - scenarios used in other aspects of planning – show risks and vulnerability
 - how can you manage/plan to maintain flexibility (flood plain development, water supply)
- **Our decisions based on historical statistics not modelling**
 - need to recognize that past climate no longer reliable guide to future
 - explore implications of climate change scenarios
- **We don't have time or money to deal with climate change now**
 - climate change influences frequency, intensity, extent and/or magnitude of existing problems
 - hedge against potential impacts and "no regrets" adaptations