

# Influences in the Lake Superior Basin

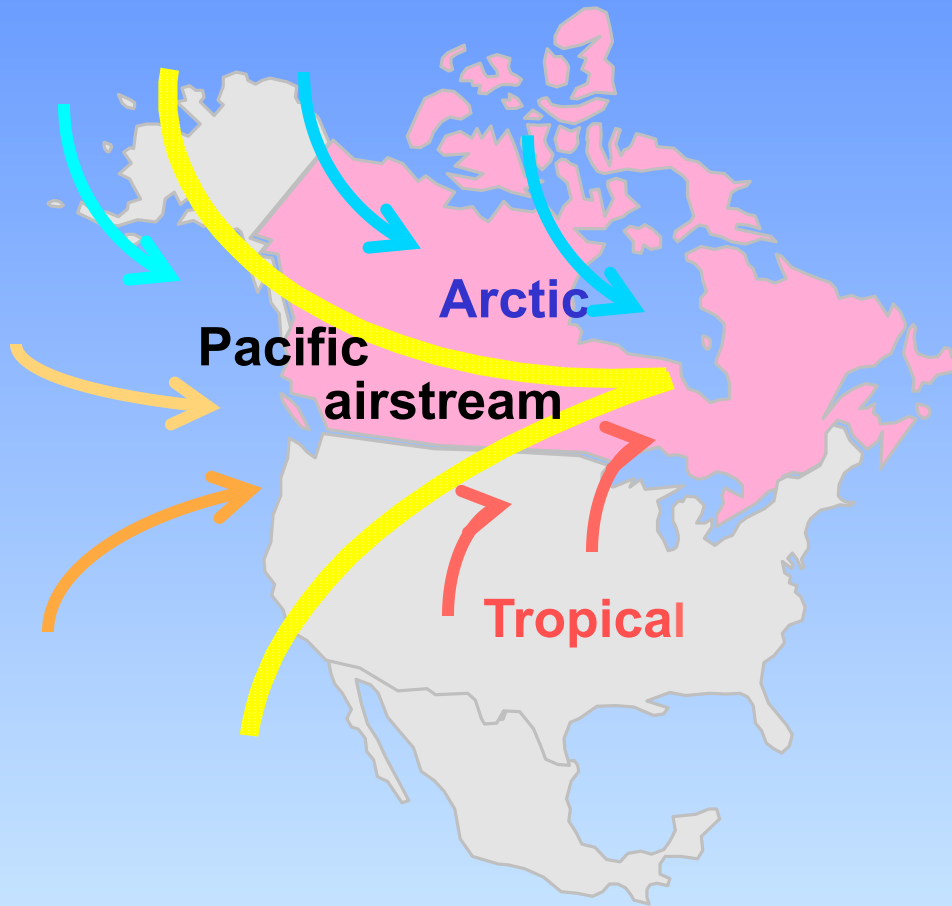
- General climate conditions
- Seasonal weather conditions
- Lake stratification and turnover
- Influences on lake levels
- Climate change impacts:
  - Observed
  - Forecast

# General Climate Conditions

Factors that affect weather in the Lake Superior basin:

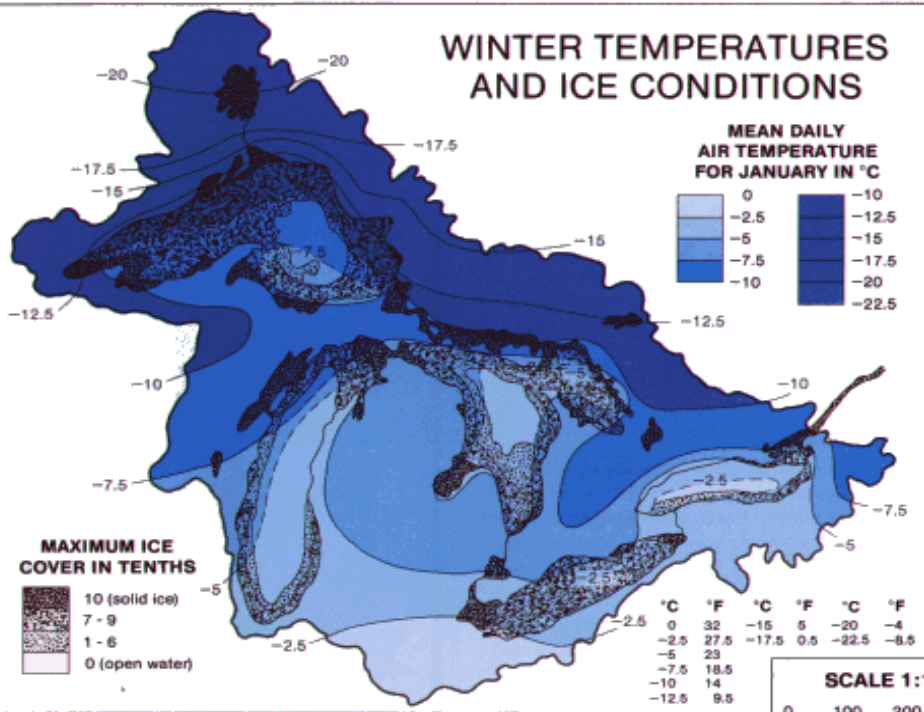
1. Air masses from other regions
2. Location of basin within a large continental landmass
3. Moderating influences of Lake Superior

# Climatology of Central North America

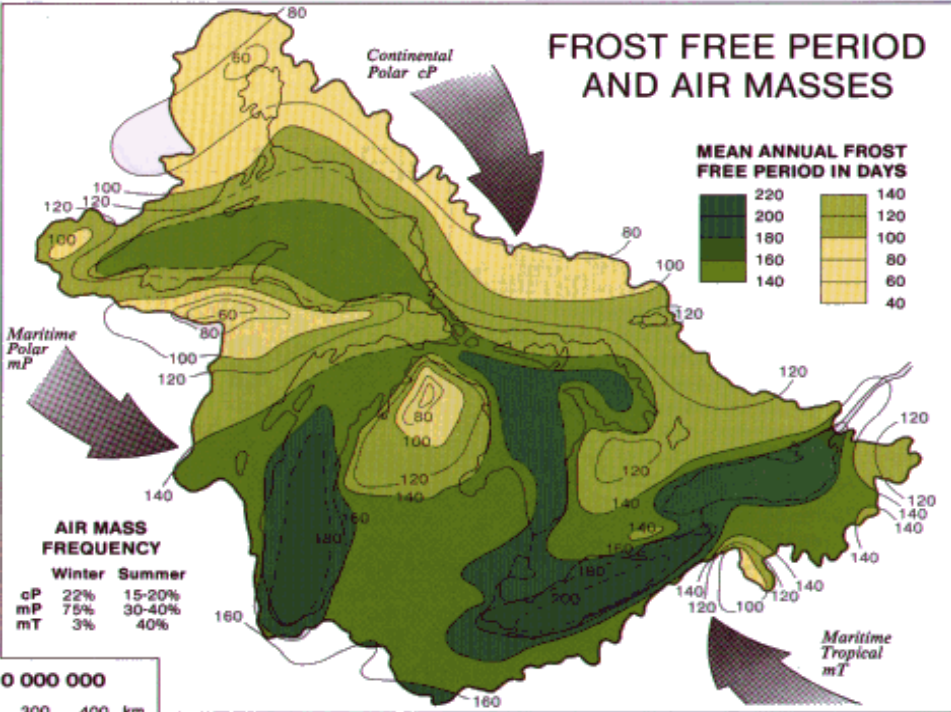


- Latitude
- Altitude
- Westerlies
- Air masses
- Continentality
- Lake Superior

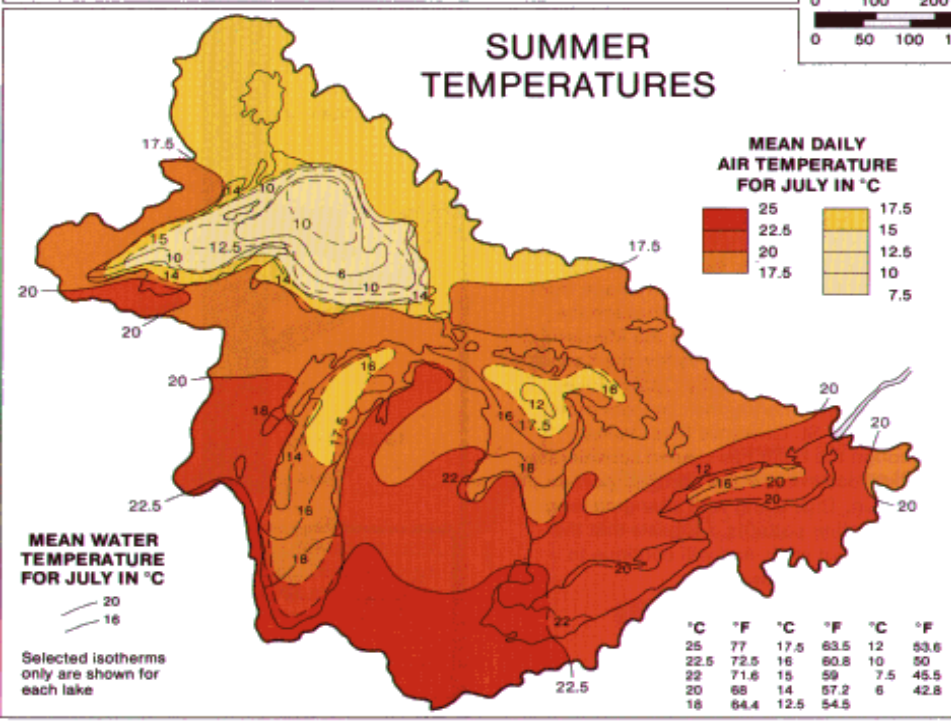
## WINTER TEMPERATURES AND ICE CONDITIONS



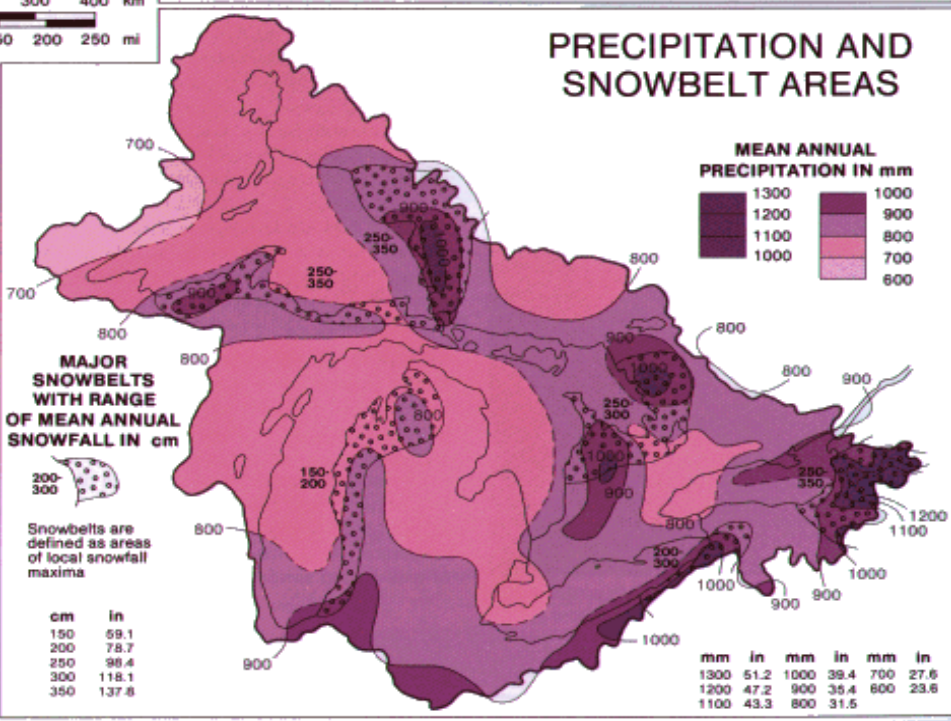
## FROST FREE PERIOD AND AIR MASSES



## SUMMER TEMPERATURES



## PRECIPITATION AND SNOWBELT AREAS



# Temperature Connections

## *The Big Picture*

- global air circulation, air masses, frontal systems

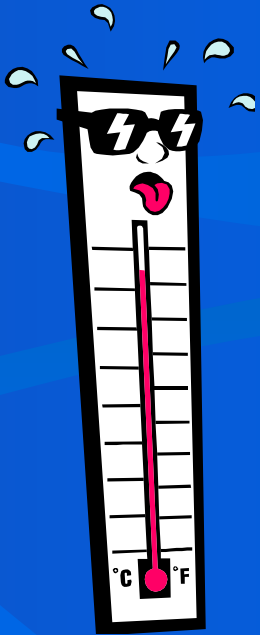
## *Regional Features*

- wind, clouds and precipitation, fog

## *Local Effects*

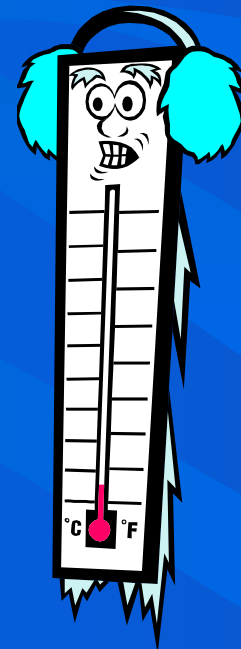
- often result from contrasts in temperature  
examples: fog and lake breezes

# Temperature



Water Temperature

Air Temperature



# Water Temperature



**4° Celsius**

**Spring overturn**

**Fall overturn**

# Lake Processes: Stratification And Turnover

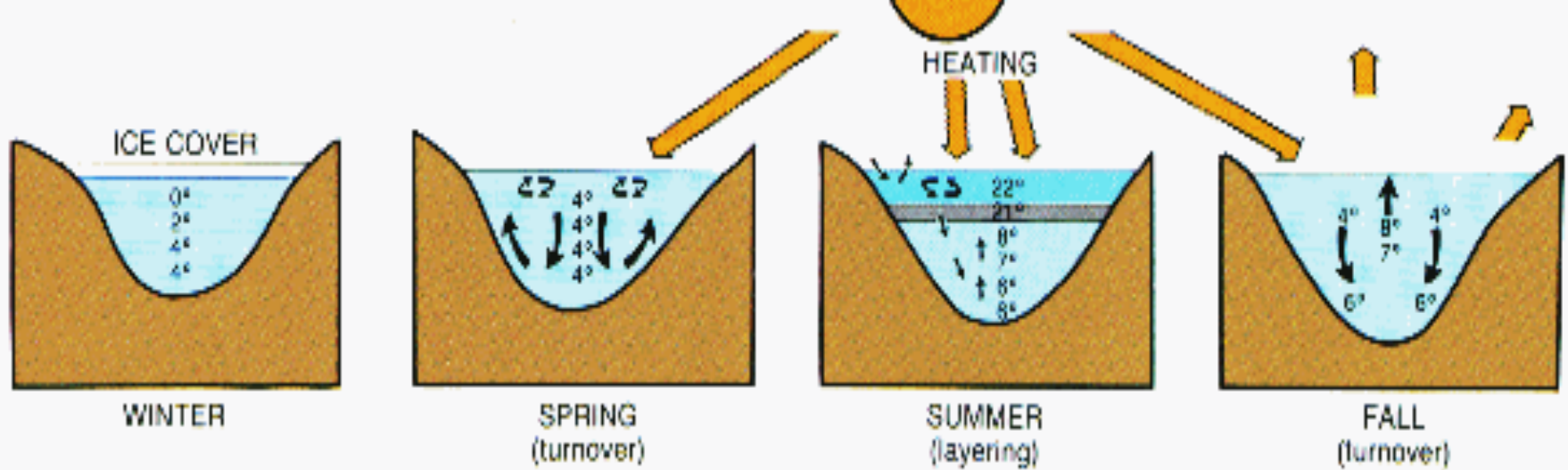
- Not uniformly mixed water but highly dynamic systems with complex processes
- Variety of subsystems that change seasonally and on longer cycles
- Stratification takes place due to density changes caused by changes in temperature



# Lake Processes: Stratification And Turnover

Stratification is due to density changes caused by changes in temperature

- Density increases as water decreases until a maximum density of about 4 degrees C
- Causes thermal stratification (deep layers in summer)
- Deepest layer is the ‘hypolimnion’
- Surface and shoreline areas are warmest (‘epolimnion’)
- A thin middle layer (‘thermocline’) develops as a rapid transition in temperature occurs during the summer months



## Lake Stratification (Layering) and Turnover.

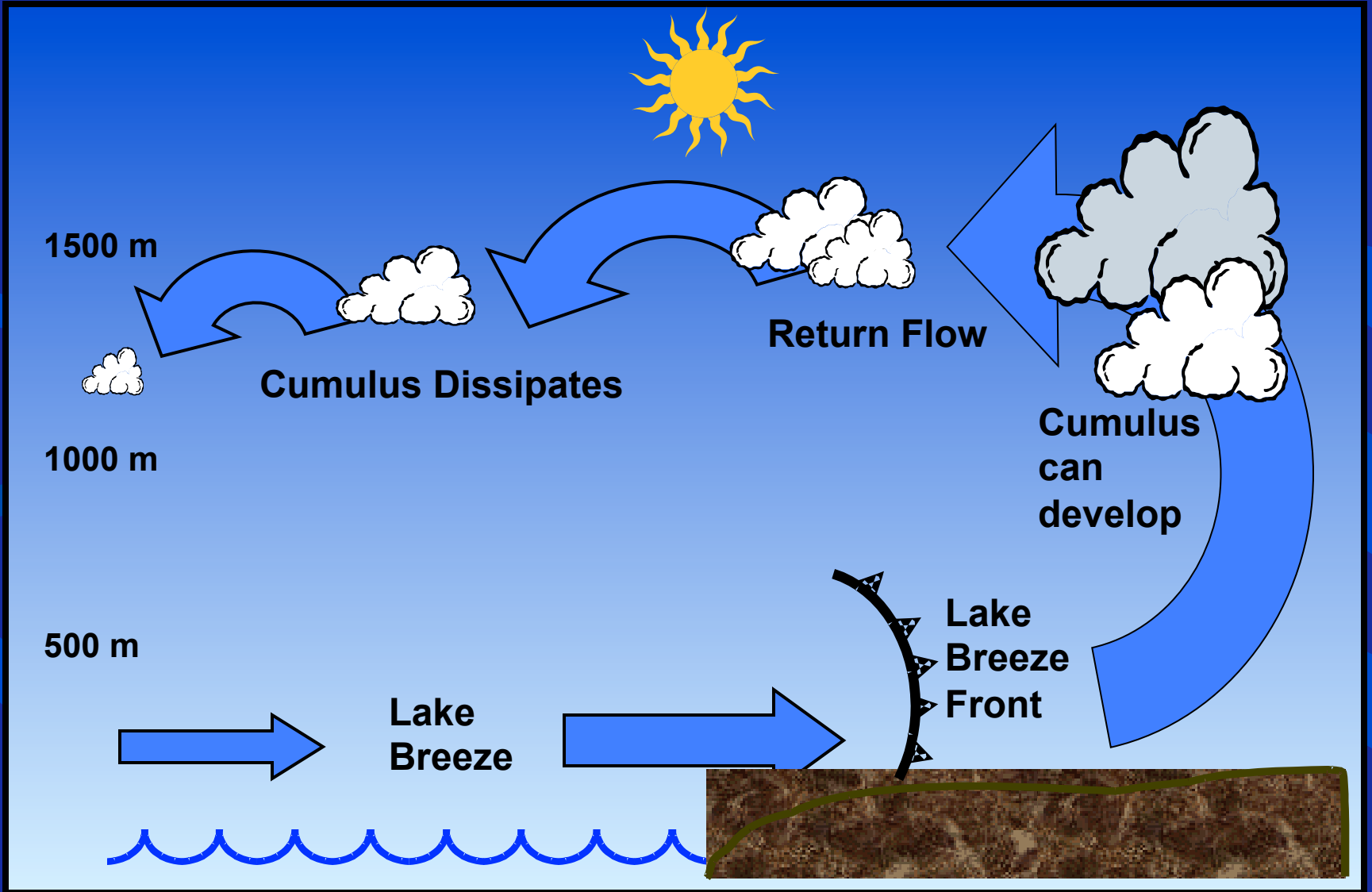
Winter: ice cover stays at 0°C and the water remains warmer below the ice than in the air above.

Spring: turnover occurs as surface water warms to 4°C, sinks and displaces cooler lower water upward. In Lake Superior this takes place in June.

Summer: stratification occurs with the formation of distinct layers (epilimnion / hypolimnion and the thermocline transition)

Fall: surface waters cool, become denser and descend as heat is lost from the surface.

# Lake Breezes

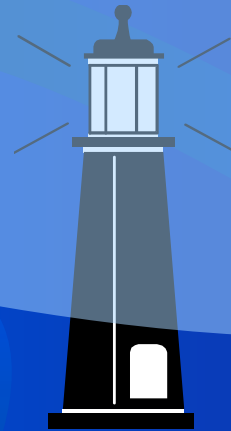


# Types of Fog

Advection

Radiation

Precipitation



# Thunderstorms

Air mass

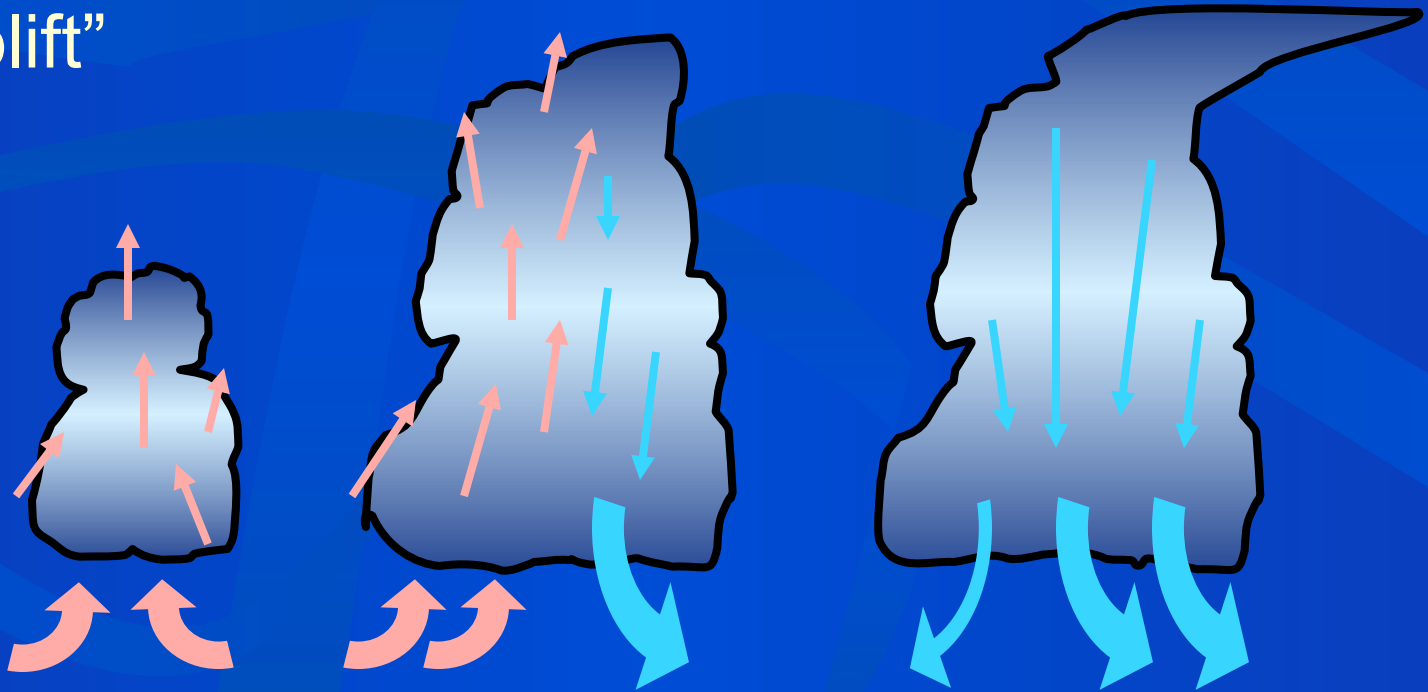
Frontal



# Thunderstorms

Formation:

- unstable air conditions
- moisture content
- “uplift”



# Severe Thunderstorms

## *Formation:*

- very unstable air conditions
- high “dewpoints”, i.e. high moisture content
- combinations of lift
- cumulonimbus clouds - considerable vertical development

## *Consequences:*

- intense precipitation including hail
- strong and gusty winds
- intense lightning
- waterspouts (rare)

# Winds and Waves



Wave height depends on:

- wind speed
- wind duration
- fetch

Significant Wave Height

(to be discussed more in connection to the Slate Island Lab)



# Boating History

- Early inhabitants: Algonkian people (Laurel and Woodland periods)
- Ojibwe
- Voyageurs (fur traders)
- Prospectors
- Fishing
- Logging
- Recreation

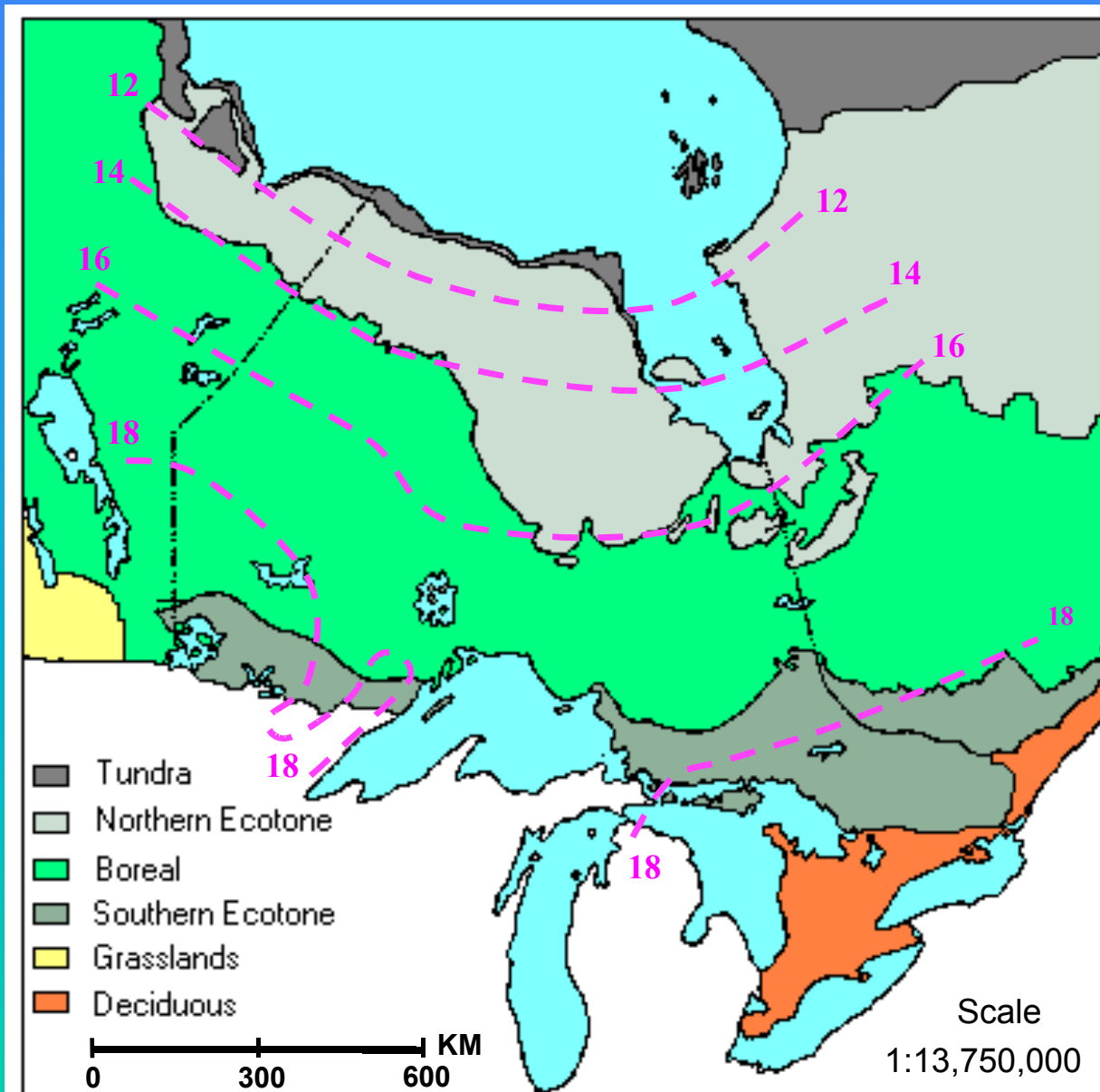
# Lake Levels

- Air masses carry water (precipitation) into the Basin
- The Basin loses moisture in departing air masses by evaporation and transpiration
- Water loss through the regulated flow out of Lake Superior
- Over time, the quantity lost equals quantity gained, with great variability over the short-term (i.e. seasonal)
- Long-term trends correspond to long-term trends in precipitation and temperature

# Climate Change Impacts

- GCMs determine the manner in which increased CO<sub>2</sub> emissions affect the Lake
- Doubling of CO<sub>2</sub> the basin could warm 2-4 degrees C
- Damper than present
- Increased evaporation from lake surface
- Increased evapotranspiration from land surface
- Augment precipitation returned to atmosphere
- Net basin supply decrease of 23-50% (1/2 - 2 m)

# Present location of boreal forest



# Adaptive Strategies?



# Implications for the boreal forest

*Migration*

flora and fauna

*Disturbance:*

fire

insects

disease

blowdown

competition

*Fragmentation*

# Discussion

- Reduced risk
- *No regrets options*
- COP 21 Paris (December)
- Failures in the past . . . This time?