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# Ice Jam Formation

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# River ice season in cold regions

## Two well-defined periods of dynamic hydrological activity:

- Freezing in autumn
- Breakup typically in spring

## Intermediate period of relative hydrological calm:

- Declining flows
- Increasing ice thickness



# River ice breakup

*The decay, fracture, transport, and removal of the river ice cover, that is, the entire process commonly called a **breakup**, is complicated and varies greatly between rivers, between stretches of the same river, and between winters*

- Beltaos, 1995

# River ice breakup

## Short definition

The seasonal disintegration and movement of river ice.

## Influences river dynamics

Ice breakup affects river flow, the risk of flooding, and environmental impacts along waterways.

## Importance in hydrology

Understanding ice breakup is crucial for managing water resources and mitigating flood hazards.



# Types of river ice breakup

## Thermal breakup

This gradual melting process is driven by rising temperatures and sunlight, with minimal impact.

## Mechanical breakup

This sudden breakup is caused by rising water levels, increasing the risk of ice jams and floods.

# Thermal vs. mechanical breakup

## Thermal breakup

This gradual melting is driven by rising temperatures and sunlight, resulting in a slow and predictable ice breakup. It usually poses little risk of ice jams, as gradual melting allows water levels to rise safely.

## Mechanical breakup

This sudden breakup is caused by rising water levels that exert pressure on the ice cover. Combined with factors such as wind, debris, and obstacles, this can trigger rapid, forceful ice breakup. Ice fragments may then move downstream, **forming ice jams and increasing flood risk.**

# What are ice jams?



## Ice jam definition

Ice jams are temporary *blockages* in a river or stream caused by the *accumulation of ice*. They can significantly raise water levels and create sudden, flash flood-like conditions.



## Key components

The *severity, timing, and overall occurrence* of ice jams are critical factors that influence the risk and impact of associated flooding events.



## Comparison to flash floods

Like flash floods, ice jams can arise quickly and pose a high risk of sudden, catastrophic flooding to nearby areas and infrastructure.





Time-lapse footage of how a partially frozen river in New York rose rapidly during a cold period (cold wave)



# Timing of ice jam formation

## Breakup jams

Breakup jams typically occur in **late winter** or **early spring** and are often the most severe type of ice jam event.

## Freeze-up jams

Freeze-up jams can form at any point during the **winter** when the river ice cover develops.

## Midwinter thaws

Ice jams can also develop during "**midwinter** thaws" when a sudden rise in temperature causes the ice to loosen and begin moving.



# What controls ice jam formation?



## Thermal conditions

Air and water temperatures impact the formation, growth, and breakup of ice cover on the river.



## Hydrological conditions

River discharge, water levels, and flow velocities influence the movement and accumulation of ice.



## Mechanical Conditions

Factors like ice thickness, strength, and cohesion affect how the ice cover responds to external forces.



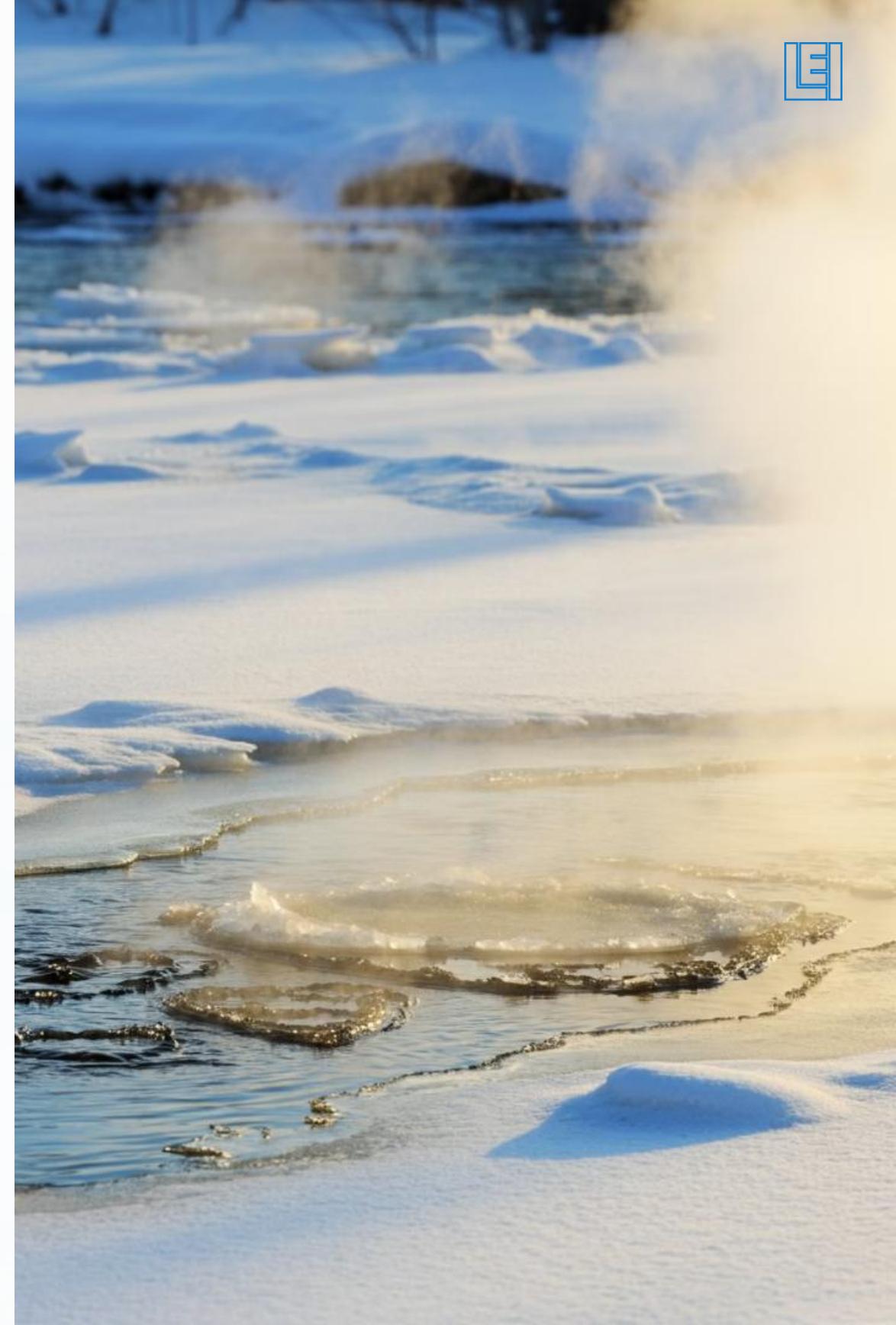
# Thermal conditions

## Air temperature & wind

Air temperature and wind are crucial factors that directly impact the rates of ice formation and deterioration.

## Shortwave radiation

Shortwave radiation from the sun affects the mechanical strength of the ice, making it more susceptible to breakup and the formation of ice jams.



# Hydrological conditions

River runoff response is controlled by snowmelt and rainfall

river  
discharge



water  
levels



flow  
velocities



The **power**, **height** and **speed** of the river water that determine whether ice stays still, moves downstream, or piles up into a jam



# Mechanical conditions

## River channel morphology

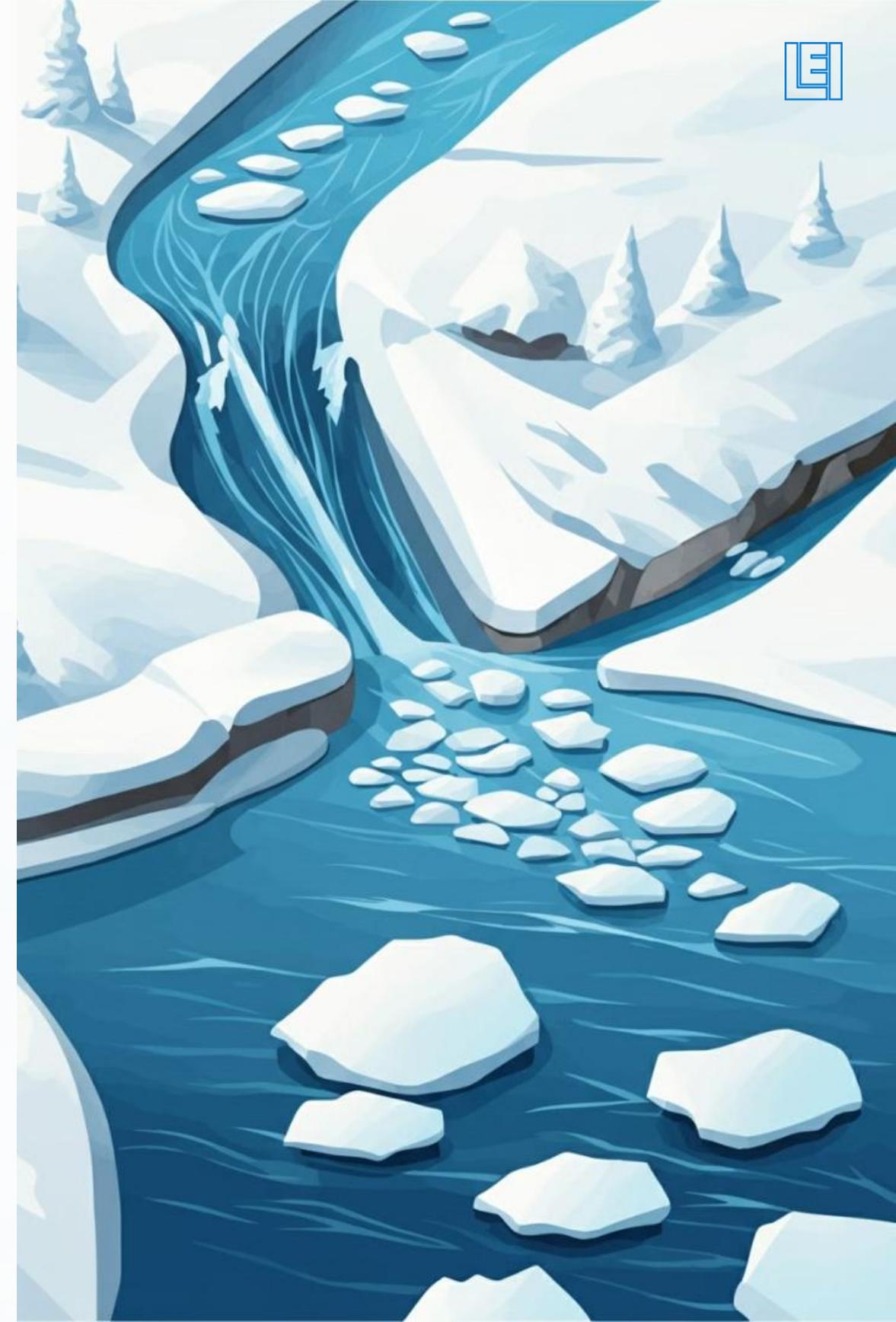
The shape and flow patterns of the river channel can influence where and how severe ice jams form.

## Flow resistance

The roughness of the channel and any accumulated ice can increase flow resistance and contribute to jam formation.

## Ice volume & strength

The volume and structural integrity of the ice floes and blocks are key factors in the extent and severity of ice jams.



# River channel morphology and ice jams

The morphology of a river's channel can significantly influence the location and formation of ice jams. Specific areas with obstacles, constrictions, or sharp bends are more prone to ice accumulation and flooding during breakup events.

Rivers that have experienced ice jams in the past are also more likely to see future recurrence, as the river's physical characteristics remain unchanged.



# Obstacles leading to ice jams



## Natural obstacles

Naturally occurring features like islands, river narrowing, and meanders can impede the flow of ice, leading to the formation of ice jams.



## Human-made obstacles

Artificial structures, such as bridges, culverts and other infrastructure, can also act as obstacles, disrupting the natural flow of ice and contributing to ice jam formation.



## Nonuniform ice cover

Uneven patterns of ice cover decay and breakup can create blockages and obstructions, causing ice to accumulate and form jams.

# Challenges in predicting ice-induced floods

## High variability

Ice jams form rapidly and in localized areas, making them difficult to predict accurately.

## Complexity of factors

The formation of ice jams involves a complex interplay of thermal, hydrological, and mechanical conditions that are challenging to model.

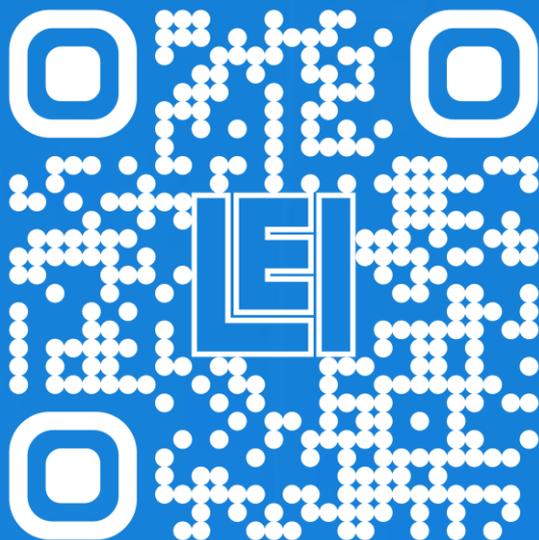
## Impact of climate change

Warmer winters and increased precipitation may lead to more frequent and severe ice jam events.





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