Master project (CFD): Snow sublimation – wind tunnel simulations using state of the art computational toolboxes.
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Introduction

The Cold Climate Container is a unique modular laboratory facility and workshop designed to simulate atmospheric, hydrological and biological processes at high latitudes. The container has advanced instrumentation for studying ice formation and generating artificial snow that mimics a range of natural snowfall properties (e.g. habits). The lab allows for long-term experiments investigating how ecosystems respond to varying temperatures and snow covers.
https://www.mn.uio.no/geo/english/research/about/infrastructure/facilities/workshops/geosciences/climate-container/index.html

Hydropower has a *significant role in Norwegian energy system*, which deliver *green energy* to the societies. Snow is the largest reservoir in many *hydropower* systems. This snow reservoir is leaking water to the air by the process known as sublimation, that is the direct loss of snow to the atmosphere due to phase transition of snow to water vapor. Snow that sublimates is lost from hydropower production. But what is the actual amount of "lost snow"?

As a part of the SnowSub project https://www.mn.uio.no/geo/english/research/projects/snowsub/ *Process level experiments in the Cold Climate Container will be used to characterize sublimation under controlled conditions. The sublimation experiments will be conducted in the sublimation box installed in the Container, which consist of wind tunnel resting on the box filled with nature-identical snow.*

Aim and Objectives

The aim of the project is to investigate the possibilities of state-of-the-art fluid dynamics packages (Fenix, OpenFoam, Fluent) to simulate air flow in a channel, where the boundary conditions on one of the walls are specified by a rough snow surface. The flow is multiphase and the snow media is porous with properties changing over time. To achieve the objectives of the project, the student will:

1. Define snow as a material and investigate its properties under different flow conditions.
2. Create a suitable mesh for the simulation environment.
3. Conduct parallel experiments to test various hypotheses and flow properties in a laboratory setting.

Methods

The methodology will consist of several phases:

1. **Literature Review & Initial Setup**:
    - Conduct a comprehensive literature review on snow sublimation, fluid dynamics, and related computational methods.
    - Installation and familiarization with CFD tools (Fenix, OpenFoam, Fluent).
2. **Material Definition & Property Investigation**:
    - Define snow as a material within the simulation environment.
    - Characterize its properties under different flow conditions.
3. **Mesh Creation**:
    - Develop and validate suitable mesh structures for the simulation.
4. **Simulation & Validation**:
    - Run simulations to analyze air flow dynamics over a rough snow surface considering multiphase nature of flow and changing snow properties
    - Validate simulation results with experimental data obtained from the laboratory.
5. **Data Analysis & Hypotheses Testing**:
    - Analyze simulation and experimental data.
    - Test different hypotheses/flow properties derived from the lab experiments.

Expected Competences

At the beginning of the project, the student is expected to have:

- A foundational understanding of fluid dynamics.
- Basic knowledge of computational fluid dynamics (CFD) tools and techniques.
- Proficiency in programming and data analysis (e.g., Python, MATLAB).

By the end of the project, the student will have gained:

- Advanced expertise in using CFD tools such as Fenix, OpenFoam, and Fluent.
- Practical experience in defining material properties and creating simulation environments.
- Skills in validating simulations with experimental data.
- Enhanced data analysis and hypothesis testing abilities.