ARCFRESH
(Arctic Freshwater Budget)

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Supported via ESA/AO/1-12062/23/I-NB *CLIMATE-SPACE - THEME II: CROSS-ECV ACTIVITIES contract number: 4000145884/24/I-LR*

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Abstract

ARCFRESH (Arctic Freshwater Budget) is a joint research project funded by ESA through the Climate Space ITT call. The project utilizes data from several CCI ECV projects to estimate the freshwater fluxes and budget of the Arctic Ocean.

Introduction

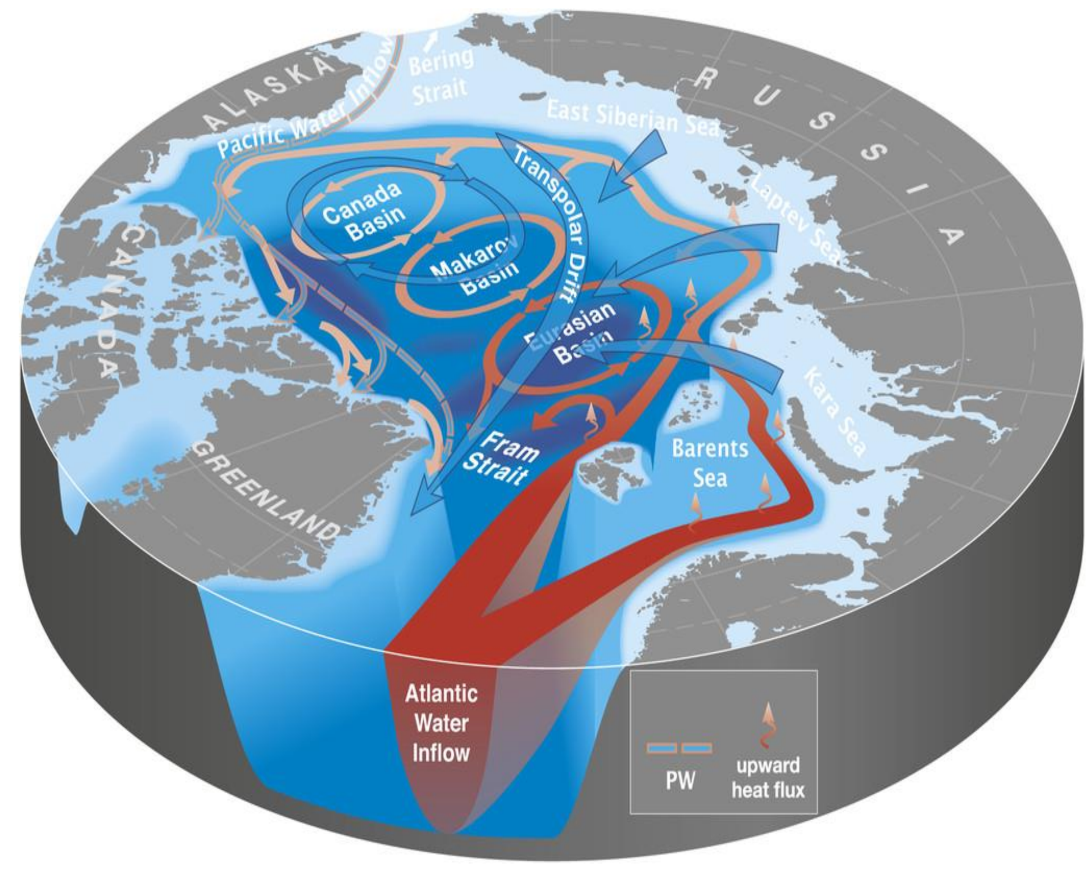
Understanding and monitoring the Arctic Ocean freshwater budget is crucial for predicting and adapting to climate change, as the Arctic region is highly sensitive and serves as a flagship area of the Earth's climate system (IPCC AR6, 2021). The freshwater fluxes in the Arctic Ocean contribute to the global thermohaline circulation, also known as the ocean conveyor belt. Changes in the freshwater budget can disrupt this circulation, which plays a crucial role in redistributing heat around the planet and can have cascading effects on regional and global climate patterns (IPCC, 2021). Variations in freshwater content influence ocean circulation patterns, including the Atlantic Meridional Overturning Circulation (AMOC), which impacts the transfer of heat between the equator and the polar regions, influencing climate conditions in adjacent areas and affecting weather patterns at lower latitudes (Rahmstorf et al., 2015).

Knowledge gaps

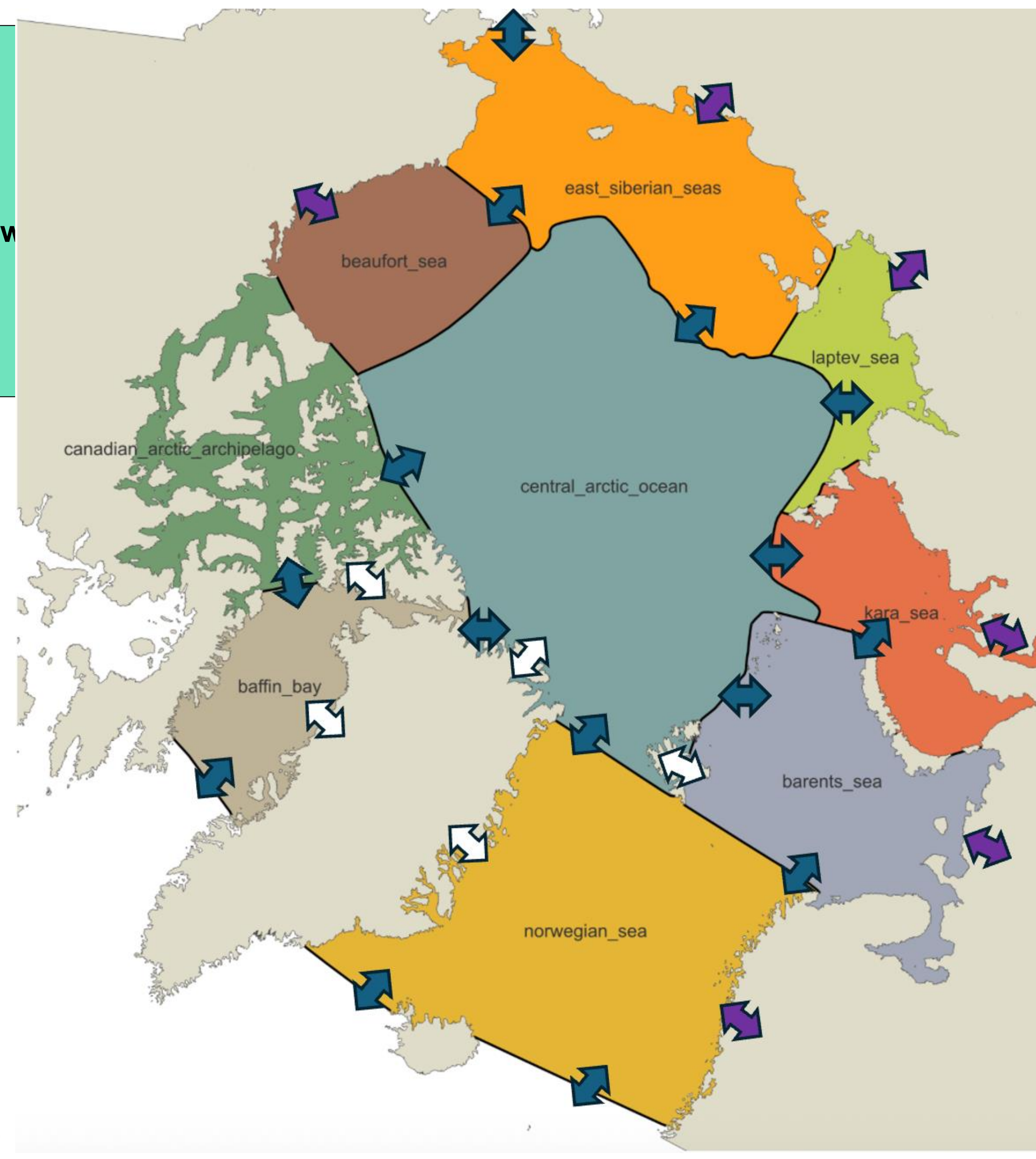
- The IPCC sixth assessment report highlights the need better to understand freshwater input and its impact on ocean circulation. This includes challenges of quantifying freshwater inputs from melting glaciers, ice caps, and permafrost into the Arctic Ocean, which affect its salinity, circulation, and, consequently, global climate patterns. As an example, there is currently there is *low confidence* in an AMOC weakening due to low agreement between observations and models (IPCC, 2021).
- Significant uncertainties persist in accurately determining regional patterns, variations, and distinct contributions to the variability of freshwater content. This highlights the importance of sustained monitoring of rivers and oceans, utilizing both satellite observations from space and direct measurements on-site. (Solomon et al, 2021)
- The GCOS Implementation Plan 2022 highlights that, despite advancements in long-term water cycle monitoring, significant gaps remain in closing the water budget and ensuring consistent assessments across various scales.
- Dorigo et al (2021), identify knowledge gaps related to uncertainties in estimating components of the water cycle due to variability in observation techniques, the need for long-term monitoring to detect trends, and the challenge of achieving water budget closure due to imbalances in observed data. Additionally, it emphasizes the importance of integrating observations from different platforms with models to enhance our understanding of water cycle dynamics, particularly at regional and local scales. (Dorigo et al, 2021)

Scientific Topics addressed by ARCFRESH

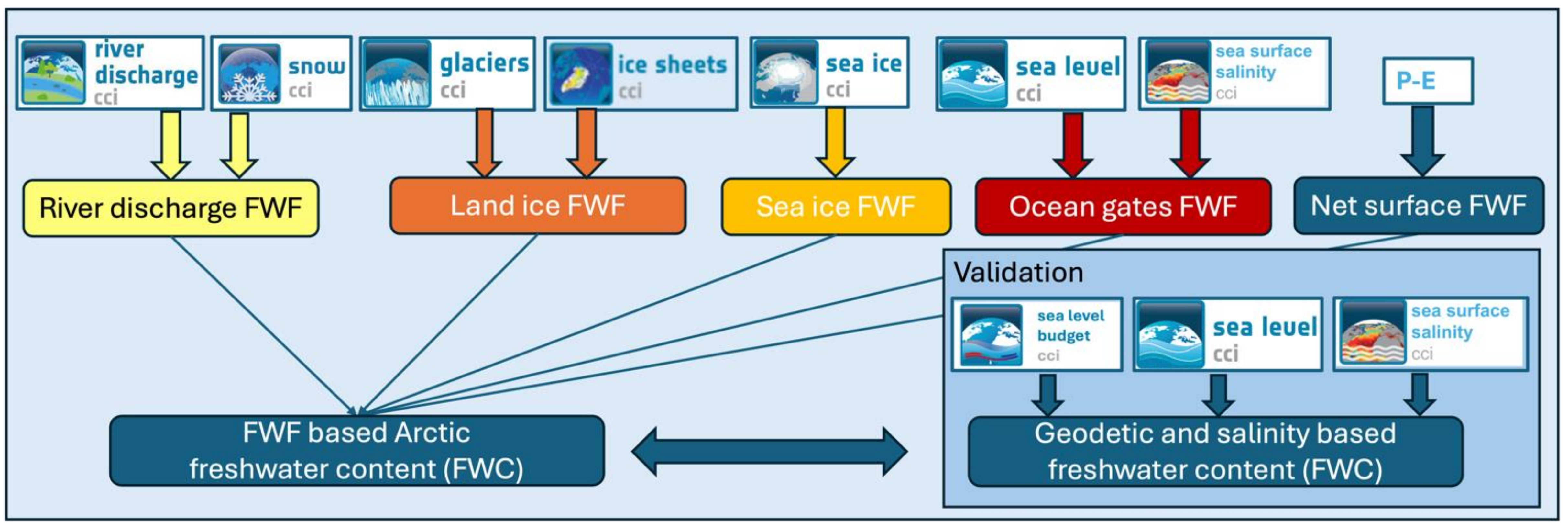
1. **Improve current estimates of lateral freshwater fluxes** between land, sea ice, and ocean in the Arctic. This topic focuses on refining our understanding and quantification of freshwater movements, critical for accurate modeling and predictions.
2. **Determine the pan-Arctic and Sub-regional Freshwater Budget** in the Arctic Ocean and its evolution in the context of a changing climate. This involves a detailed analysis of the inputs, storage, and outputs of freshwater within the Arctic system, vital for assessing global climate impacts.
3. **Investigate Extreme Freshwater Change Events**, such as an extreme Greenland or sea ice melt season, and their impact on the Arctic Ocean. This topic aims to understand the ramifications of such events on Arctic freshwater balance and broader climate implications.



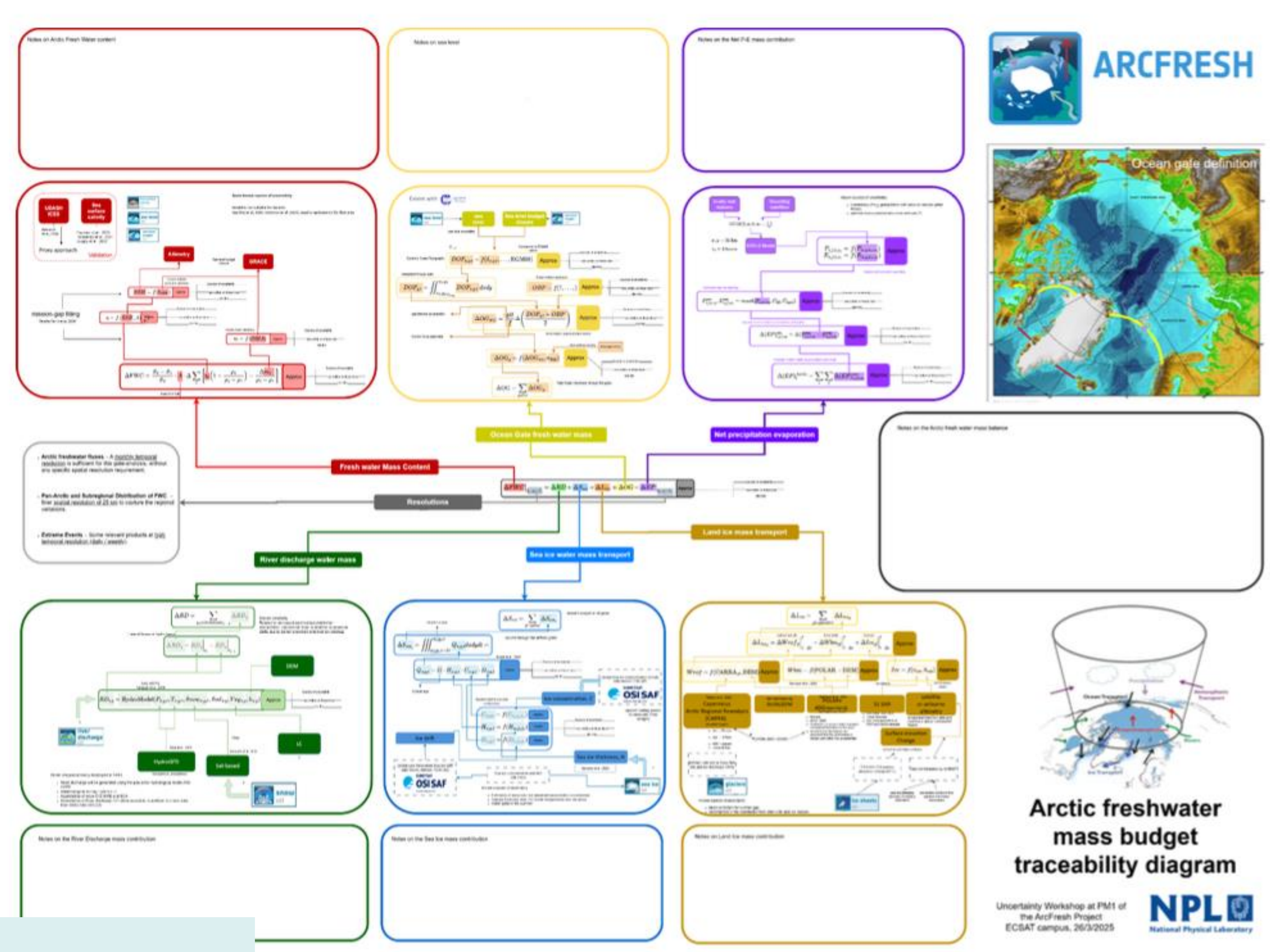
***LEFT**: schematics of the various freshwater fluxes in and out of the Arctic Ocean. In addition to water fluxes (represented by arrows), water is also stored in the form of low-salinity ocean water, sea ice, glaciers, groundwater, and permafrost. The blue region indicates the average March sea-ice extent for the period 1980–1989 from satellite passive microwave data. Figure from Snow, Water, Ice and Permafrost in the Arctic (SWIPA), 2017.*



Overview of the different gates in/out of the Arctic Ocean (ocean, land, ice)
Investigated in ARCFRESH



Schematic overview of the different CCI ECV's usage in ARCFRESH



Tracing uncertainties is fundamental in ARCFRESH: Above is Snapshot of the "uncertainty traceability diagram" for the Arctic freshwater and mass, used during the ARCFRESH uncertainty workshop in ESCAT on 25 March, 2025

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