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Also Refer to Poster-C131-1246

Developing a Glacial Surface Model for Greenland to Improve the Projections of Surface Runoff

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Integrate Observation Data into the MAR-L Simulation

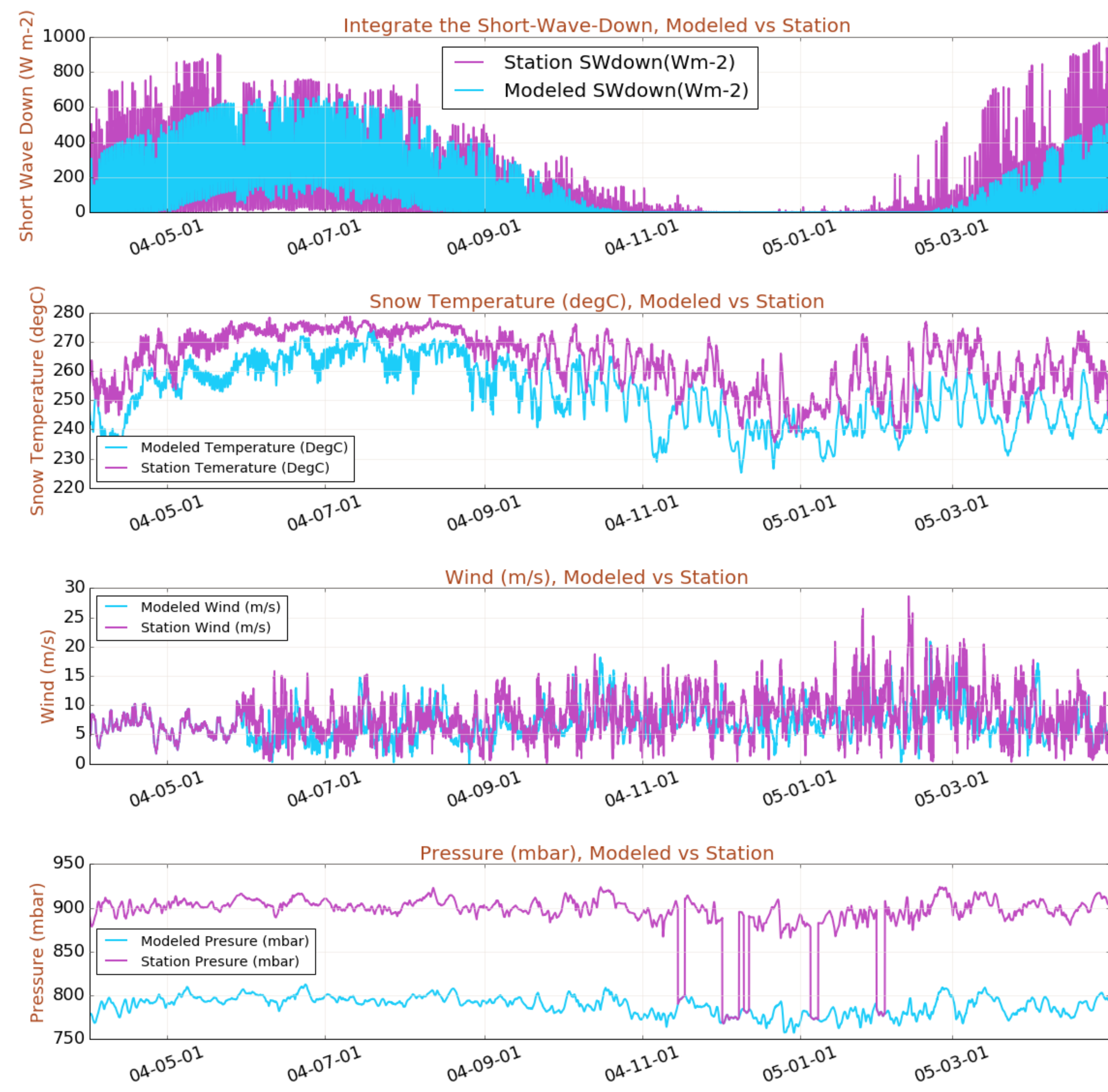
The data we obtained from the observation stations is the real measure. Taking in the data into the MAR-L model and forcing the data in the simulations, the results show us the reality of the snow and ice surface runoff and melting. Integrating the station data, we need to ensure the station data quality by QC procedures, to do math interpretations to generate a new data set to match the MAR-L data length, and to replace the original MAR simulated data with the new station data set.

Interpretation

Quality Control
Case 1: The station data is measured less frequently than the model data.
-Missing Values $Val = UpVal * (1-n/N) + LowVal * (n/N)$
-Max or Min $Where UpVal$ is the previous station data reading, $LowVal$ is the current station reading data, N is the total number of interpretations, n is the current loop in N .
Limits $Val = (Val1+Val2+...+ValN) / N$
Where Val1...ValN are all the measurements, And N is the total number of values.

Replace with the Selected Measurement Parameters of MAR-L Simulations

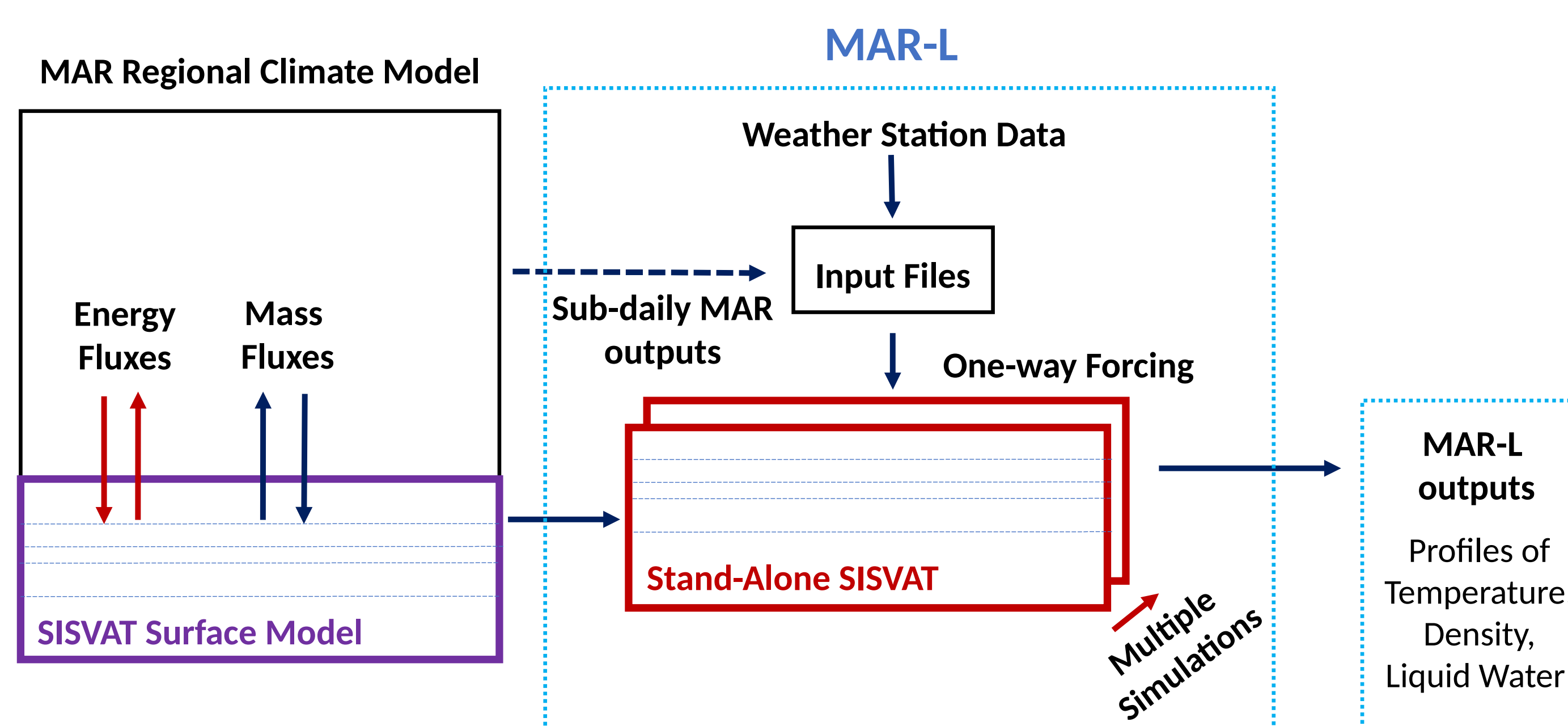
SWdown LWdown Wind Temp. Humid. Pressure Precip. Ph. SWabs Tsurf Cld



Over the past several decades, the Greenland Ice Sheet has been losing mass through a combination of increased surface runoff and accelerating ice flux to the ocean. Our understanding of the surface component is drawn heavily from satellite observations and climate models. The MAR (Modèle Atmosphère Régional) model is a 3D regional climate model used extensively in Greenland because of its proven record at simulating precipitation and firn and snowpack evolution over glaciated surfaces. Our study focuses on the surface snow and the ice down to 15-meter in depth. A light-weighted surface model for us to integrate the local observation data and force many simulations is needed. Our goal is to develop a surface-only model, derived from MAR, as a tool for understanding the glacial surface components, correlations, and MAR biases to improve projections of surface runoff. This model includes the ability to integrate observations from surface weather stations, translate the data into a model forcing format, force different simulations with various configurations or datasets, visualize model outputs, find key correlations between atmospheric drivers and modeled firn desertification.

In the model development, we extract the surface code from the full MAR for the simulations initialized and forced with the following snow and atmospheric fields: snow depth, temperature, density, water volume, and grain size. We then verify that the surface model generates the same outputs as the full MAR does if fetched with the identical data. The bias is checked with snowpack time-depth plots for multiple sites around Greenland, including Summit and Swiss Camp. We have found a very small bias when compared to the fully-coupled MAR. We perform quality control for the data inputs, such as replacing missing data from the station measurements, defining the max and min for each dataset, filtering out the data outliers by statistics standard deviations. As the result, our model software can provide multiple simulations in sequential and concurrent mode with user-friendly interfaces, and run robustly. The model's first release is currently being deployed over different sites across Greenland to understand the importance of atmospheric forcing versus snow model biases in projections of future mass loss due to surface melt.

MAR-L vs MAR

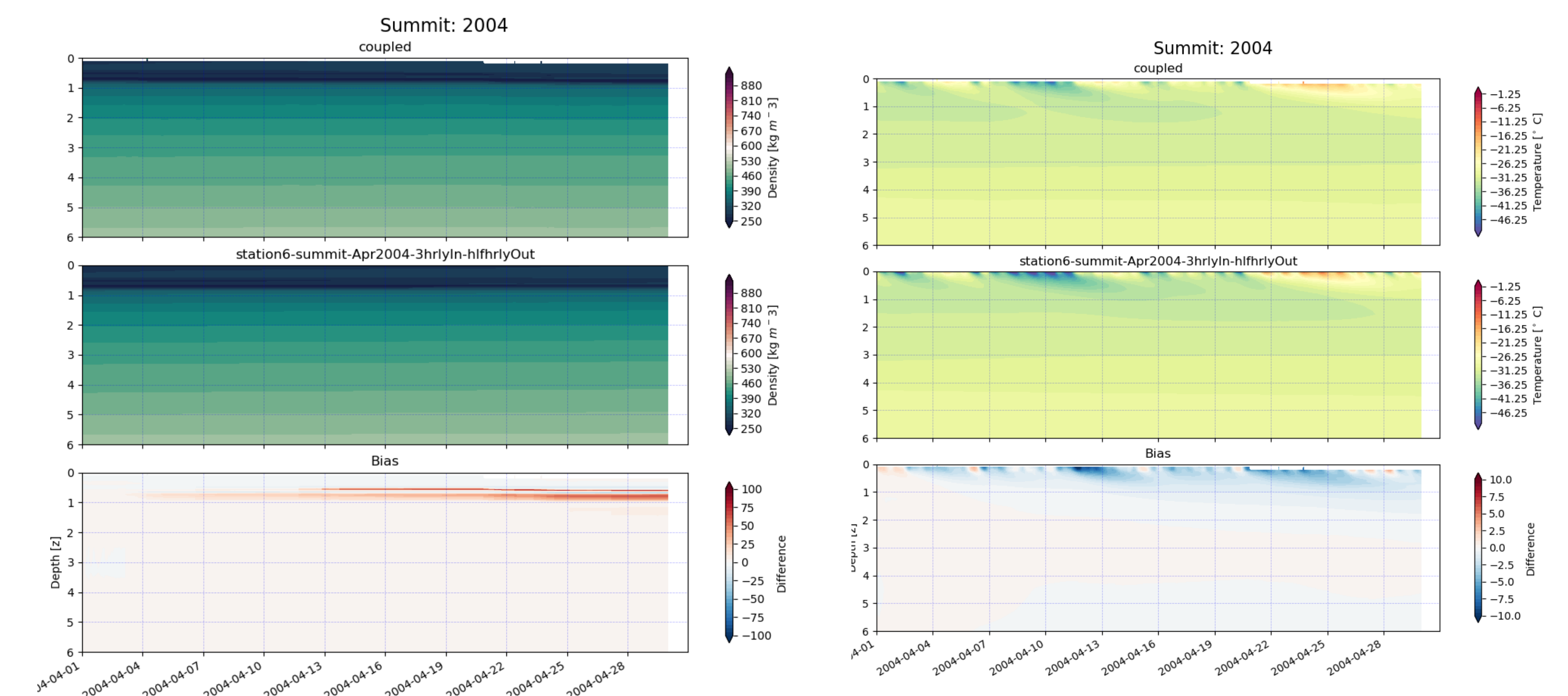


Speed and Performance Improvement in the Module Implementation

Our design of MAR-L concerns the quality and the performance. Not only we consider that the model's science, math, and physics are implemented correctly, but also the modeling speed. In station data integration, the module has been designed 3 times in 3 different approaches. The results are unbelievable: the time needed to integrate one year station data into the MAR-L input changes from 520 seconds to 5 seconds: it's 100 times faster!
From speeding a small portion of code to the simultaneous simulations, fast speed is the high-light of our MAR-L model.

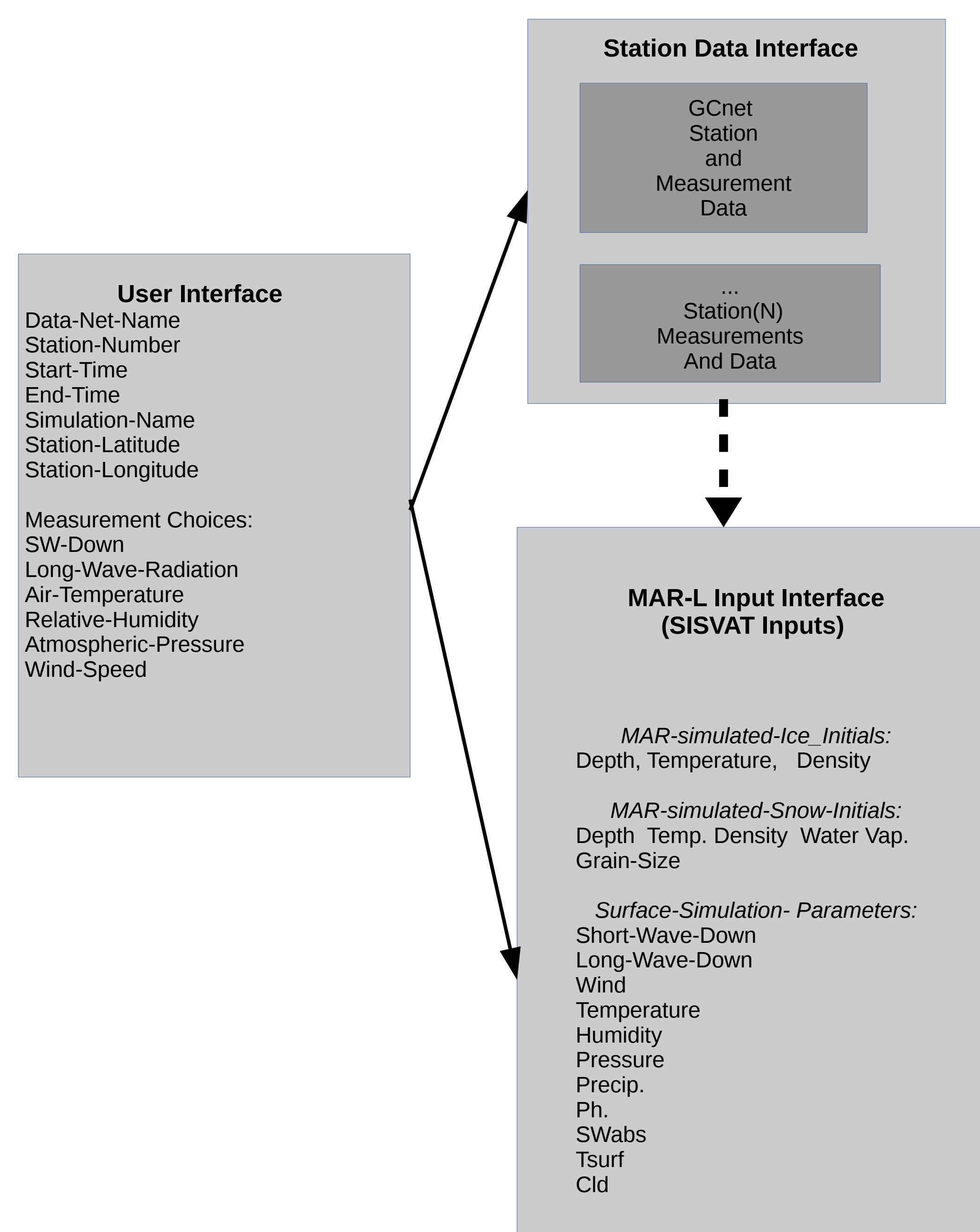
Prove the Reliability of the MAR-L Model

MAR-L is the surface subset of the MAR which has been well recognized in the cold region area because of its super performance. To make sure that MAR-L is reliable at the beginning of its development, we need to prove that MAR-L can produce same simulation as MAR when feed with the same inputs. We studied the snow depth at summer in Greenland in April of 2004, and the temperatures, by analyzing the data from MAR and MAR-L, and compared them to verify that the bias is small enough and in the tolerable rate. The biggest temperature bias is 5%, while the max snow depth bias is 2.7%, both at the top surface and affecting a small region. The images below show our results and proofs of the MAR-L accountability.

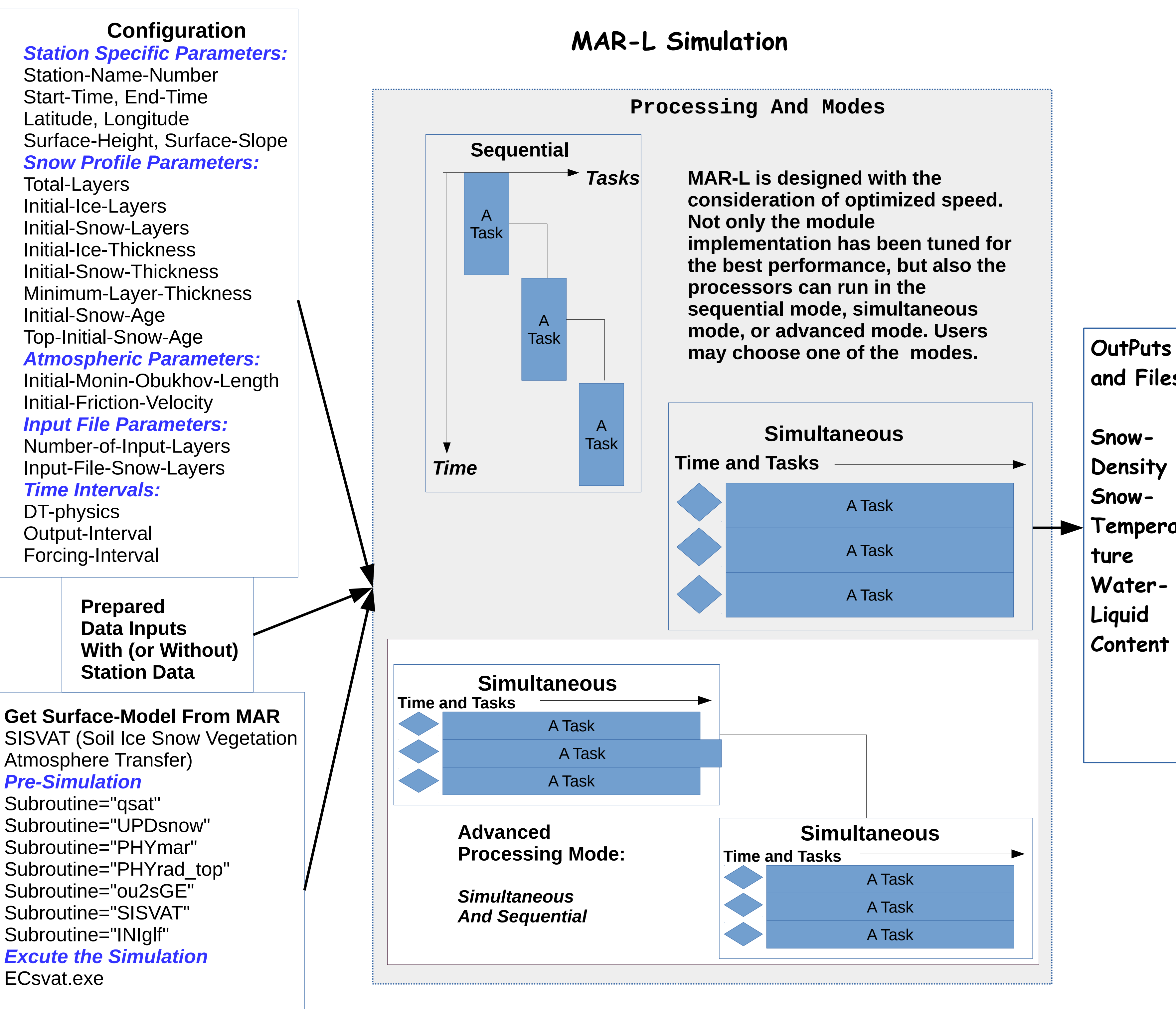


MAR-L Interfaces

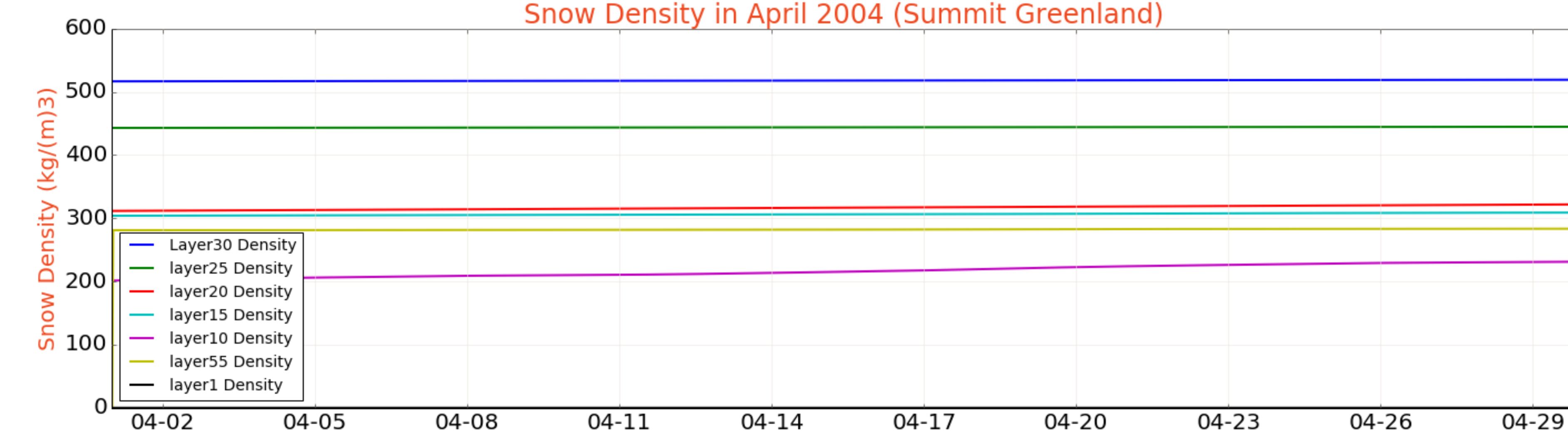
Interfacing with users for the choices of the simulation parameters, taking the MAR output as its own input, and integrating the stations' real measurements in the input, MAR-L thus forces these parameters and their data into the simulation, in generating the ice-surface data and then information for our exploring.



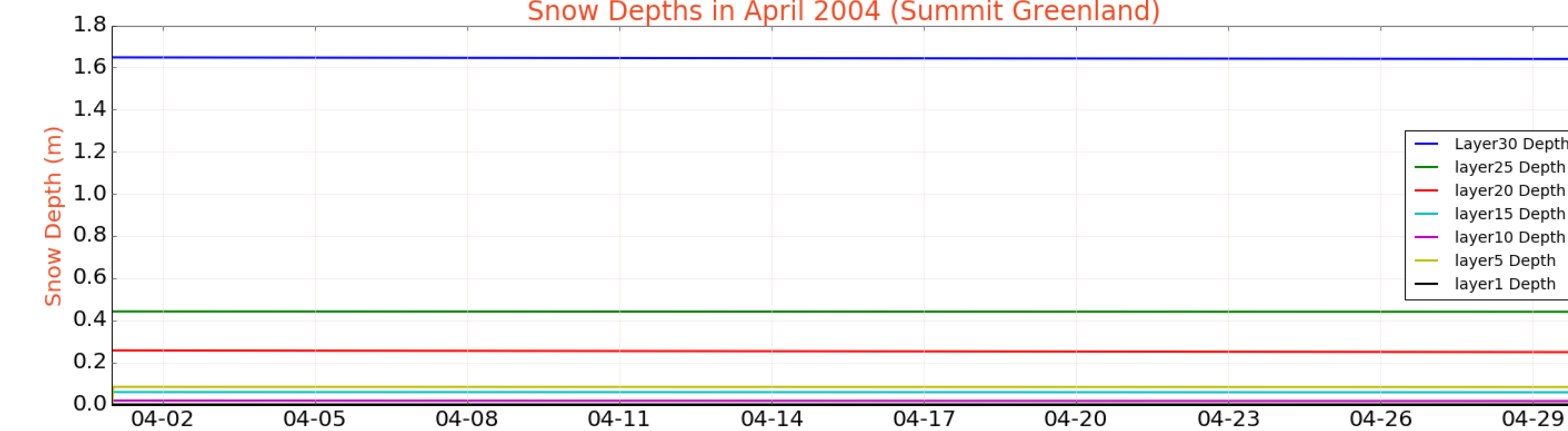
MAR-L Simulation



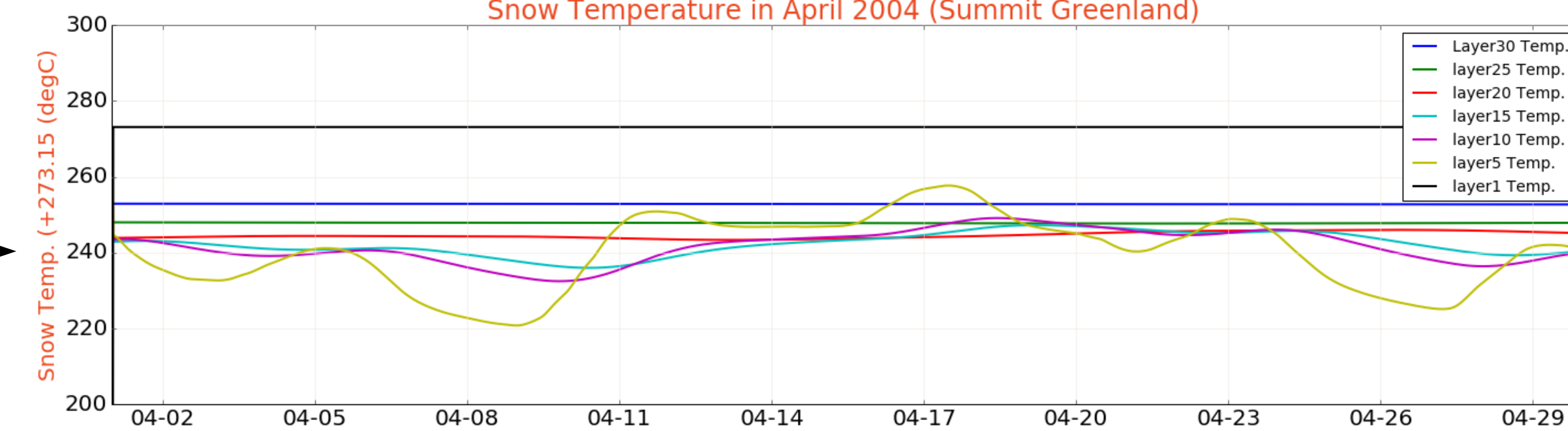
Snow Density in April 2004 (Summit Greenland)



Snow Depths in April 2004 (Summit Greenland)



Snow Temperature in April 2004 (Summit Greenland)



Water/Liquid Content in April 2004 (Summit Greenland)

