Comparing the ERA5 FLake Model to in-situ Observations on Lake Champlain

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Abstract

The ERA5 Reanalysis dataset contains a fresh water lake model (FLake). This project compares multiple variables from the ERA5 FLake model to in-situ lake and meteorological observations on Lake Champlain. The reliability and accuracy of the ERA5 model for Lake Champlain can be quantified in this process.

Introduction/Background

- The goal of this project is to compare variables from the ERA5 FLake model to in-situ lake observations from several datasets on Lake Champlain in order to quantify the accuracy of the ERA5 FLake model
- The ERA5 FLake model is a sub-grid scale lake model that simulates lake conditions for lakes across the globe
- Versions of the FLake model use many parameters to replicate lakes but lake depth is found to be the most important metric for modeling lake variables (Dutra et al. 2010)
- Other Studies have shown that when comparing a version of the Flake model to observational lake data, FLake typically delays the seasonal evolution of lake temperatures (Balsamo 2013)
- The differences which this delay creates between ERA5 and the other datasets should be quantified and further analyzed

Data and Methods

- Data from the ERA5 Climate Reanalysis, Vermont Department of Environmental Conservation (VT DEC), and the Forest Ecosystem Monitoring Cooperative (FEMC) were analyzed across the Lake Champlain region (Fig. 1)
- ERA5 has an hourly temporal resolution and 31 km spatial resolution. FEMC data was taken from two sites on Lake Champlain: Colchester Reef (CR) and Diamond Island (DI) and has a 15 minute temporal resolution. VT DEC profiles were taken approximately weekly ranging from every 2-20 days from May to October
- Water temperature, air temperature, and solar radiation were compared between ERA5 and in-situ data on Lake Champlain. Using Betts et al. (2016), a clear sky fit was constructed for the mean daily solar radiation
- A "Northern Region" and a "Southern Region", consisting of the data stations near Colchester Reef (CR) and Diamond Island (DI) respectively, were established
- The ERA5 lake temperature profiles were constructed using multiple parametric temperature profile equations and compared to the VT DEC lake temperature profiles (Mironov 2008)
- To illustrate the coupled nature of FLake to the atmosphere, Figure 2 illustrates the 10-m wind speeds impact on the depth of the mixed layer (ML) over time. As wind speeds increase the ML increases in depth, and as they decrease so does the depth of the ML

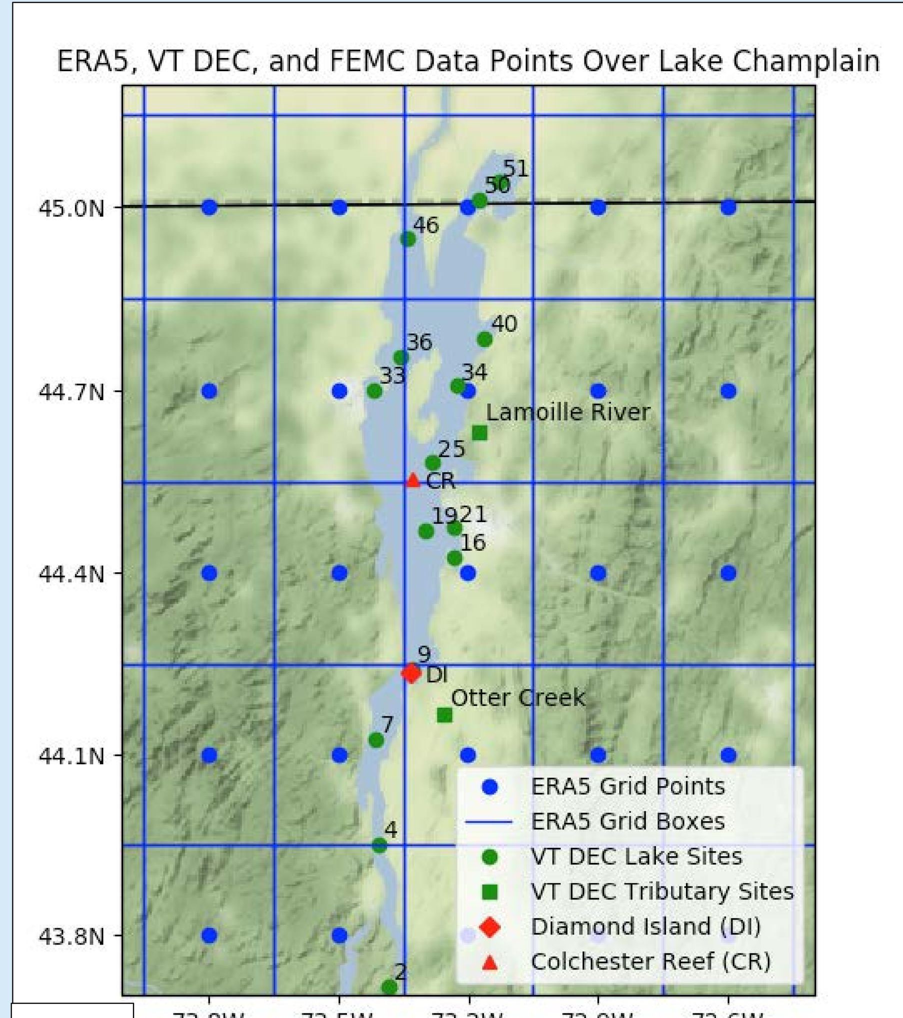
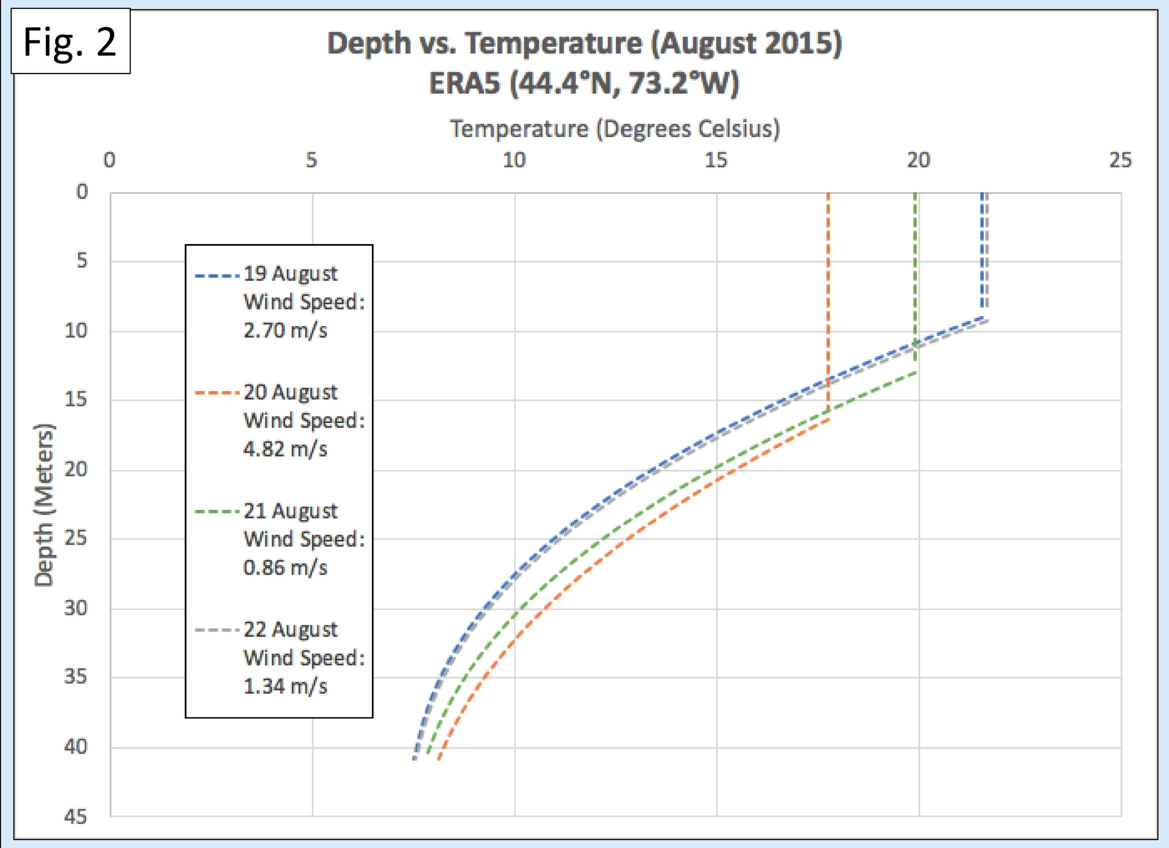


Fig. 1

Fig. 2



Results

- ERA5 is consistently a lower temperature than each of the datasets especially in Spring and Fall (same observation holds true for the Northern Region over 2015)
- River data from Otter Creek is much warmer than even the lake site data in the spring and early summer (Fig. 3). This observation holds true for 2016 as well
- ERA5 consistently overestimates the solar radiation compared to DI and CR
- By fitting the data to a curve of clear sky solar radiation (Betts et al. 2016), a +10% correction value was applied to DI and a +7% correction was applied to CR (Fig. 4). This observation holds true for 2016 as well

Fig. 4

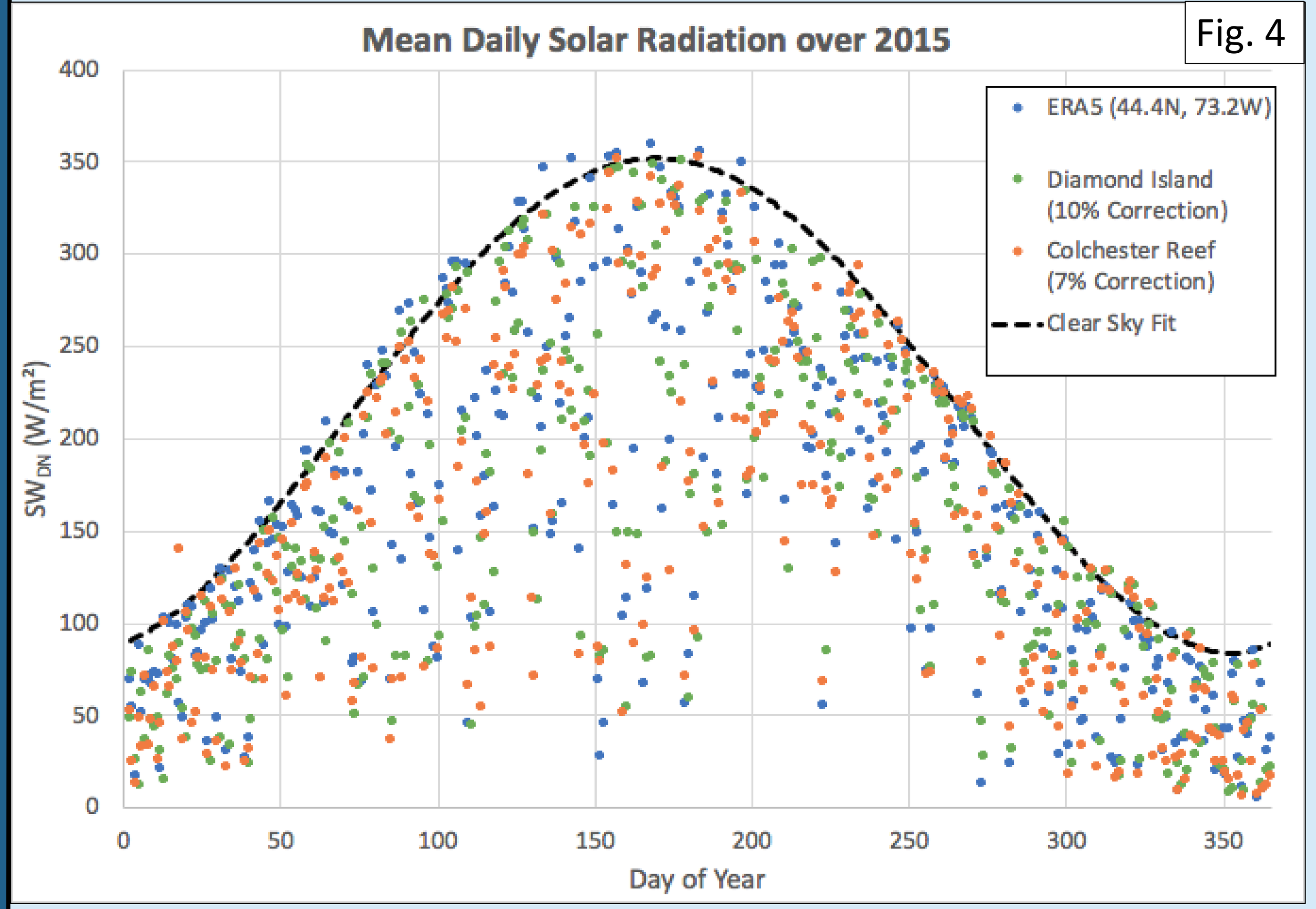


Fig. 6

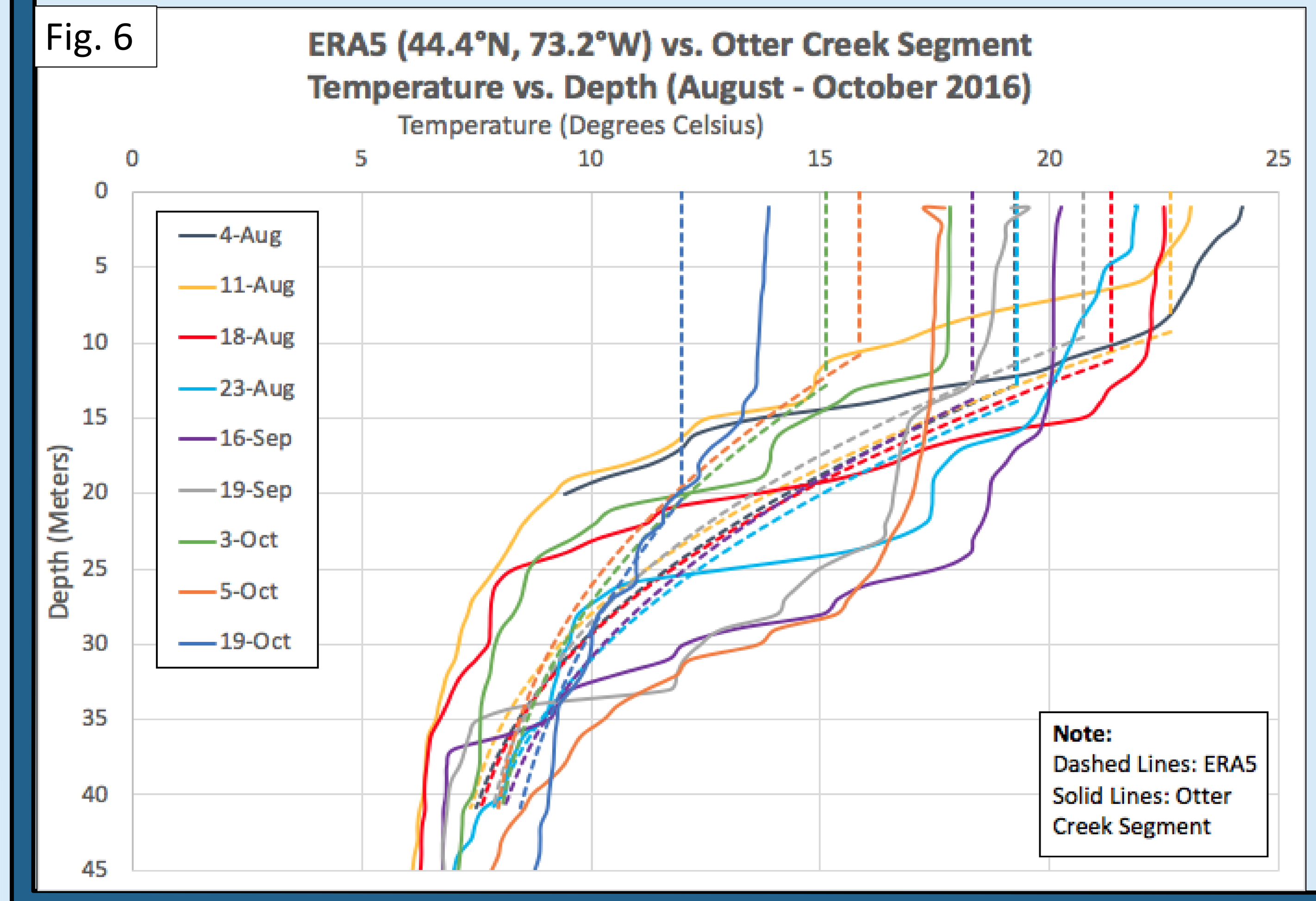


Fig. 3

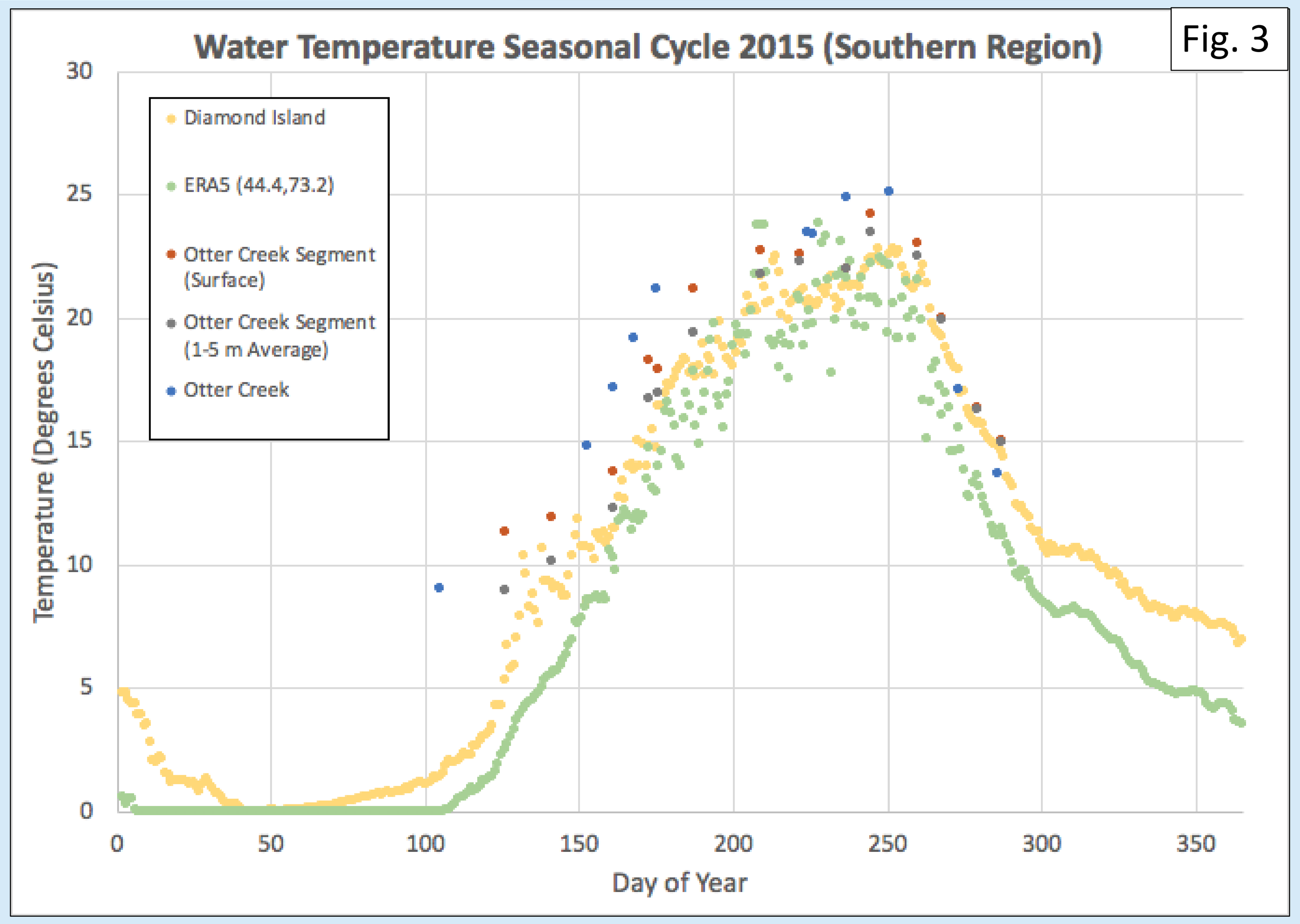
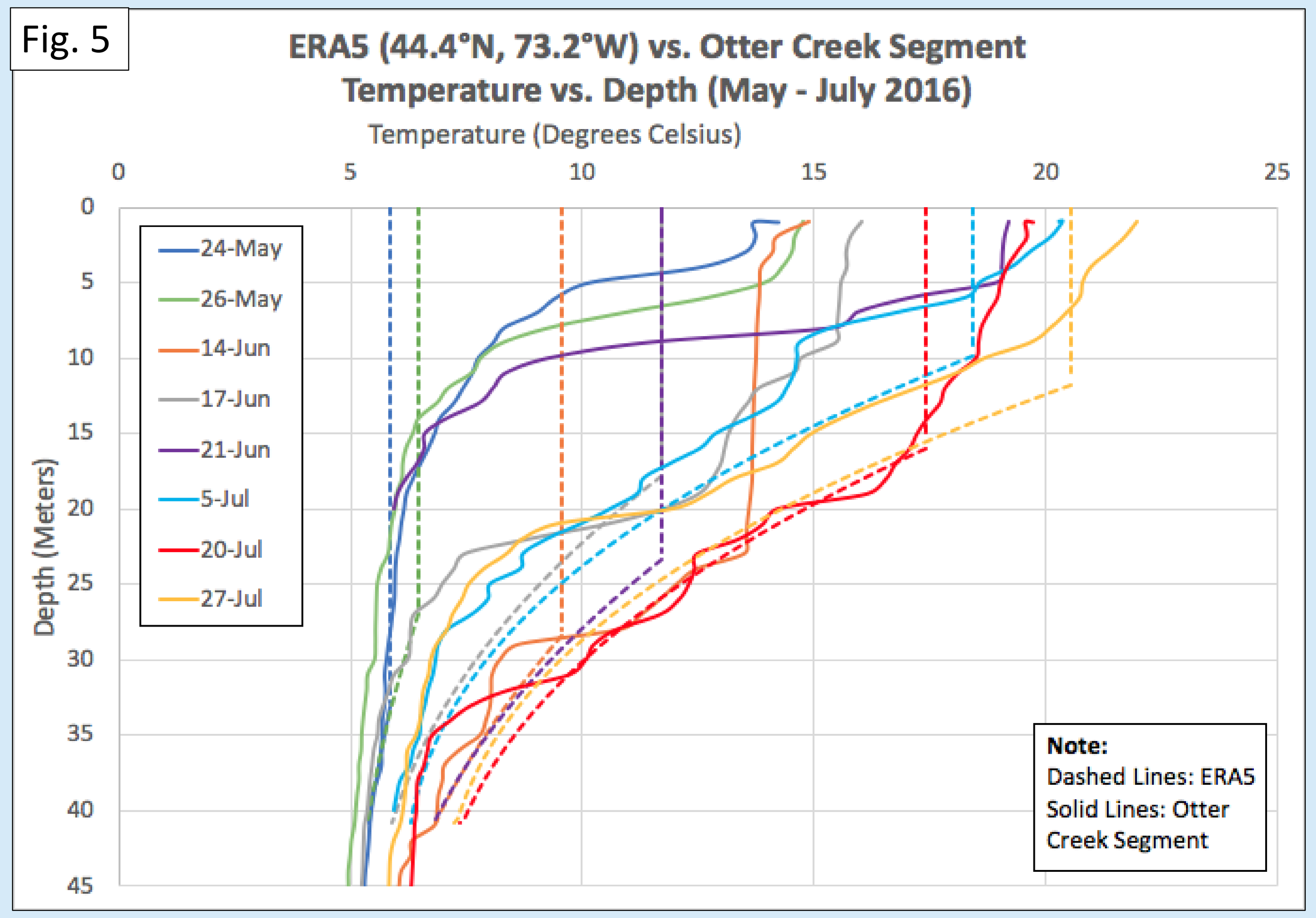


Fig. 5



- ERA5 model represents the Otter Creek Segment lake temperature profiles better in the cooling period than in the warming period (Figs. 5,6)
- Bottom lake temperatures in both ERA5 and Otter Creek typically converge to about 5–9 degrees Celsius (Figs. 5,6)
- ERA5 tends to underestimate the temperature of the lake especially in the spring and late fall (Figs. 5,6)
- Warming period displays a larger range of surface temperature values than in the cooling period (Figs. 5,6)

Discussion/Conclusions

- ERA5 is limited in its ability to replicate observations across Lake Champlain
- ERA5 underestimates the temperature of Lake Champlain especially in the spring and late fall
- Solar radiation in ERA5 may not be responsible for differences in lake temperature
- VT DEC profile data is only taken during daytime hours and has low temporal resolution which may affect its ability to match up with the higher resolution ERA5 data
- Morrill et al. (2005) has shown that during spring, warmer water in rivers flow into the lake. This observation may help explain ERA5's underestimation of lake temperatures in the spring

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