METEO 527 HW-1
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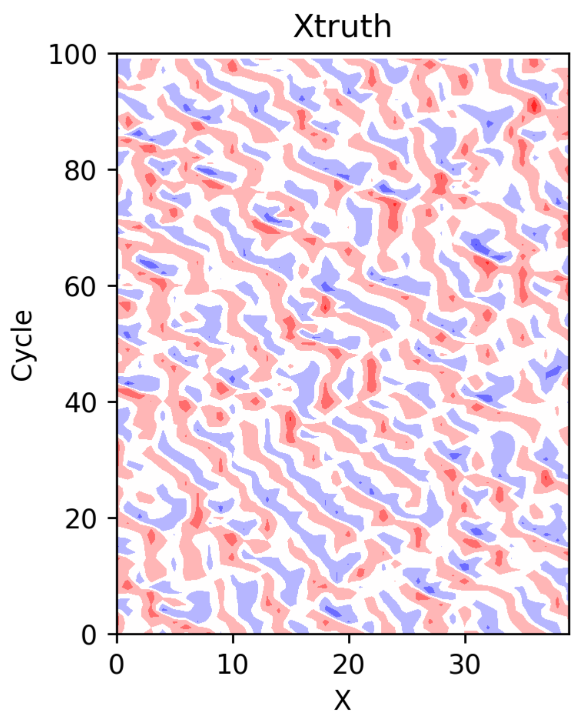
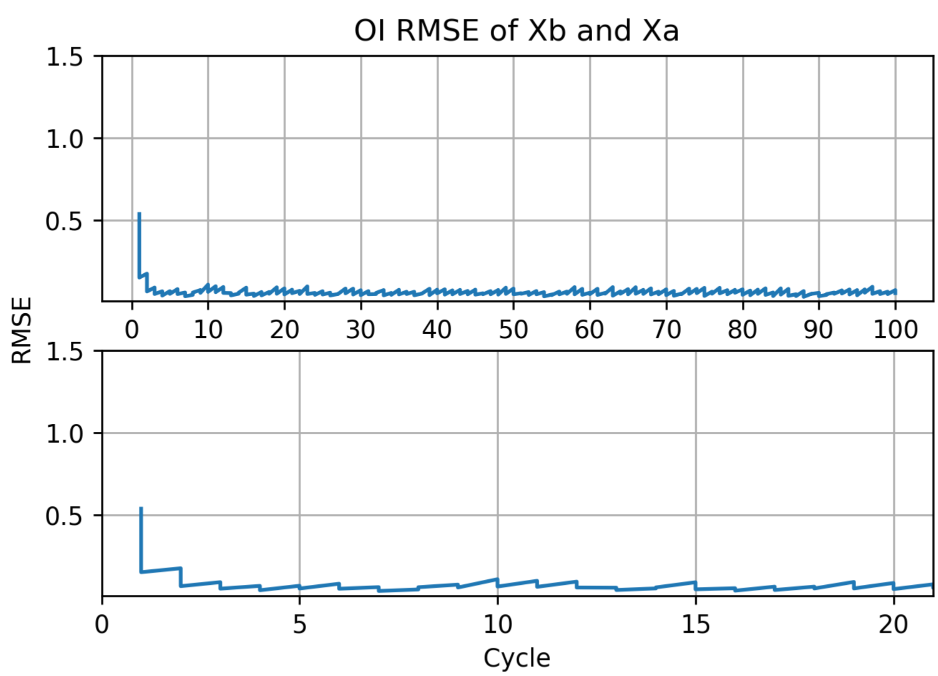
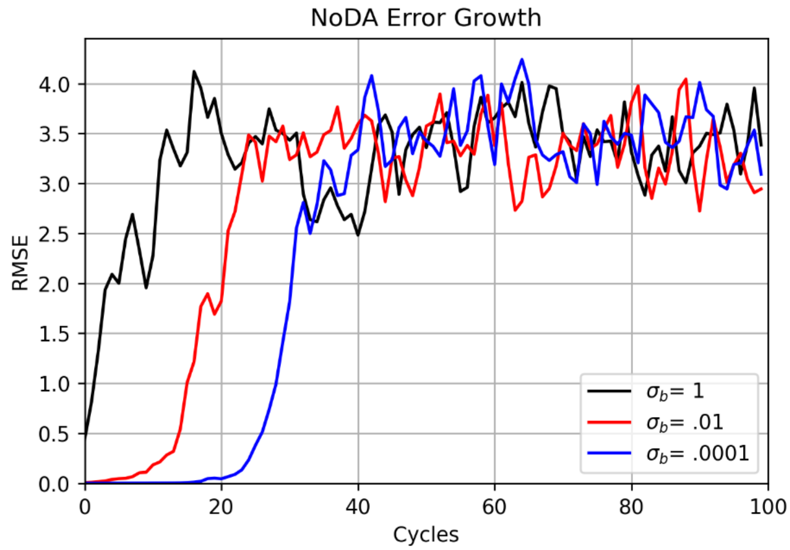
Code available at https://github.com/wefoust/Meteo527_DA

Preliminary Plots



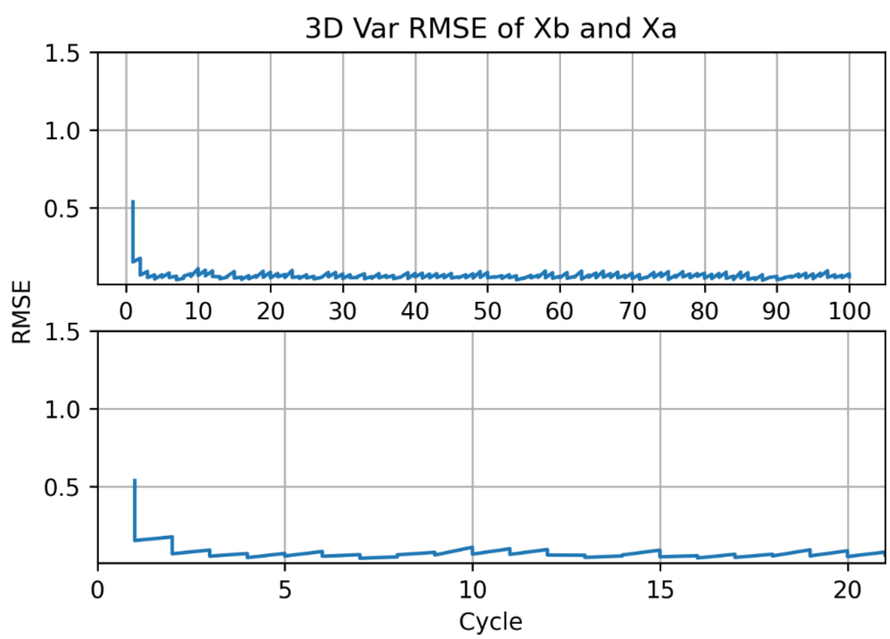


Problem 1

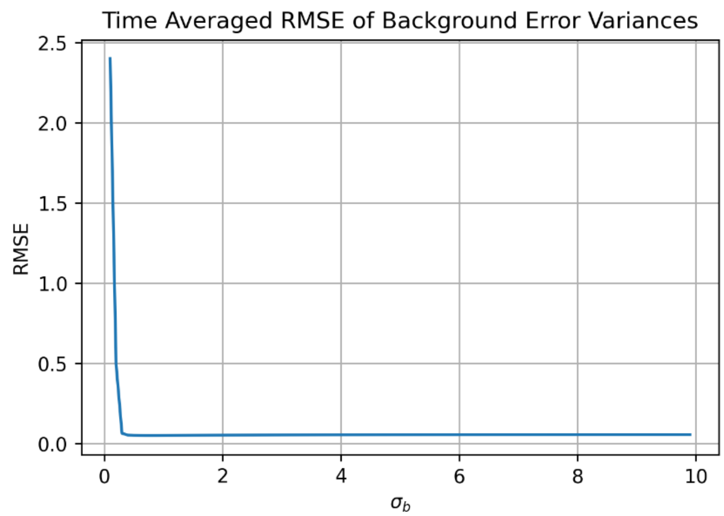


The figure depicts the model's RMSE with time in response to various initial conditions. Values of σb reflect the amplitude of the perturbation to the model's initial conditions. At t=1, the RMSE is minimal, which entails that the model solution has not diverged from the truth state. As the model propagates forward in time, the RMSE increases exponentially within the first 25 cycles and then oscillates around an asymptotic value. The graph suggests small initial errors take more time to deviate from the truth. However, any initial error will ultimately deviate enough from the truth state such it becomes decoupled with the truth and begins to resemble random error.

Problem 2

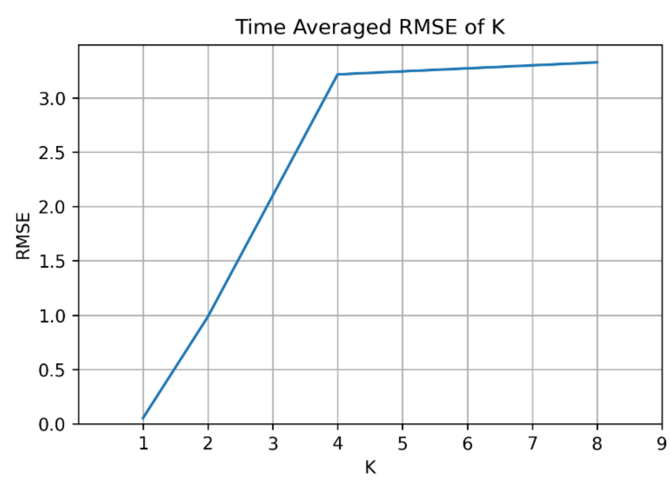


Problem 3



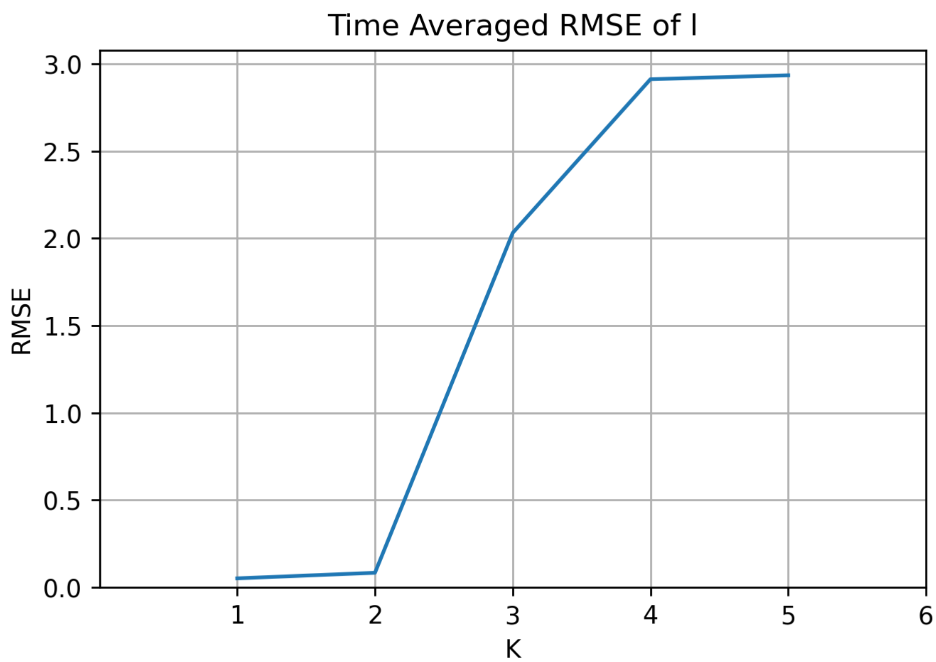
When the background error variance is small, OI or 3DVar assigns a larger weight to the background over the course of the simulation. As shown in problem 1, the background will diverge from the truth with time. Thus, the time average over the background alone will be large. As the background error is increased relative to the observation error, OI or 3DVar places more weight on the observations. Since the observations persists through time, they constrain the error growth, and the time averaged RMSE is reduced.

Problem 4



As the quantity of observations are removed, the time averaged analysis becomes less accurate as the observations fail to constrain the error growth. With fewer observations, the OI or 3DVar place stronger weight on the background. As described in Problem 3, the background error will grow in time and result in a higher time averaged RMSE.

Bonus



As l increases, the spatial correlation between background errors. This implies that proximity becomes more reliable in estimating errors, and this results in additional information for the data assimilation system being used. Mathematically, the off-diagonal values of the B matrix are increased, which results in a weaker gradient of decreasing values from the diagonal. As for the data assimilation approach, the reduction of “falloff” in the B matrix causes the background to receive a larger weight relative to observations. As described in Problem 3, relying more on the background increase the time average RMSE.