Notice of the Final Oral Examination
for the Degree of Doctor of Philosophy

of

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"Regime Occupation and Transition Information Obtained from Observable Meteorological State Variables in the Stably Stratified Nocturnal Boundary Layer"

School of Earth and Ocean Sciences

Monday, December 17, 2018
8:30 A.M.
Clearihue Building
Room B017

Supervisory Committee:
Dr. Adam Monahan, School of Earth and Ocean Sciences, University of Victoria (Supervisor)
Dr. Stan Dosso, School of Earth and Ocean Sciences, UVic (Member)
Dr. Knut von Salzen, School of Earth and Ocean Sciences, UVic (Member)
Dr. Ron McTaggart-Cowan, Environment Canada (Outside Member)

External Examiner:
Dr. Otavio Acevedo, Department of Meteorology, Universidade Federal de Santa Maria

Chair of Oral Examination:
Dr. Lenora Marcellus, School of Nursing, UVic

Dr. David Capson, Dean, Faculty of Graduate Studies

Abstract

The stably stratified nocturnal boundary layer (SBL) can be classified into two distinct regimes: one with moderate to strong winds, weak stratification and mechanically sustained turbulence (wSBL) and the other one with moderate to weak wind conditions, strong stratification and collapsed turbulence (vSBL). With the help of a hidden Markov model (HMM) analysis of the three dimensional state variable space of stratification, mean wind speeds, and wind shear the SBL can be classified in these two regimes in both the Reynolds-averaged as well as turbulence state variables. The two-regime SBL is a generic structure at different tower sites around the world independent of the location specific conditions.

Besides clustering the data the HMM analysis calculates the most likely regime occupation sequence which allows for detailed analysis of the structure of the meteorological state variables in conditions of very persistent nights. Conditioning on these very persistent nights clear influences of external drivers (such as pressure gradient force and low level cloud cover) are found. As the HMM analysis captures regime transitions accurately changes of state variables and external drivers across transitions can easily be assessed. Different meteorological state variables behave in times of turbulence collapse (wSBL to vSBL transition) and turbulence recovery (vSBL to wSBL transitions) as expected physically. The results reveal further that clear precursors for transitions in the state variable profiles or external drivers are absent and that on observed timescales regime transitions are relatively sharp.

The absence of clear precursors suggests that parameterisations of SBL regime behavior and turbulence in the two regimes in weather and climate models have to be stochastic. As regime statistics are relatively insensitive to changes in the stochastic properties of the HMM analysis observed regime statistics are compared to ‘freely-running’ Markov chains. The SBL regime statistics do not follow a simple Markov process and more complex parameterisations are necessary. A possible approach of parameterising SBL regime behavior stochastically using climatological results from this analysis is presented.