Parameter estimation for boundary-layer turbulence parameterizations over heterogeneous terrain

universität wien
Department of Meteorology and Geophysics
m.fritz@univie.ac.at

Magdalena Fritz[1], Stefano Serafin[1], Martin Weissmann[1]
1) Department of Meteorology and Geophysics, University of Vienna, Austria

High **covariances** between **u** observations and **turbulence** quantities suggest that assimilating observations along the **top** of the mountain boundary layer is most useful for parameter estimation.

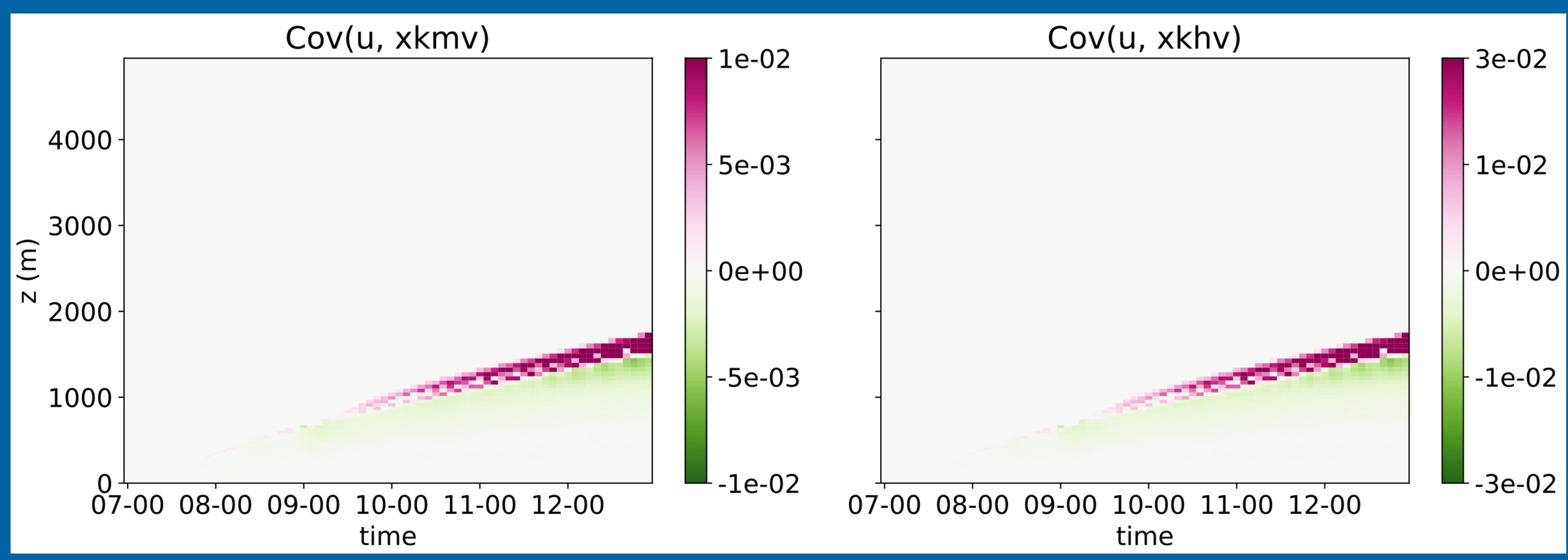


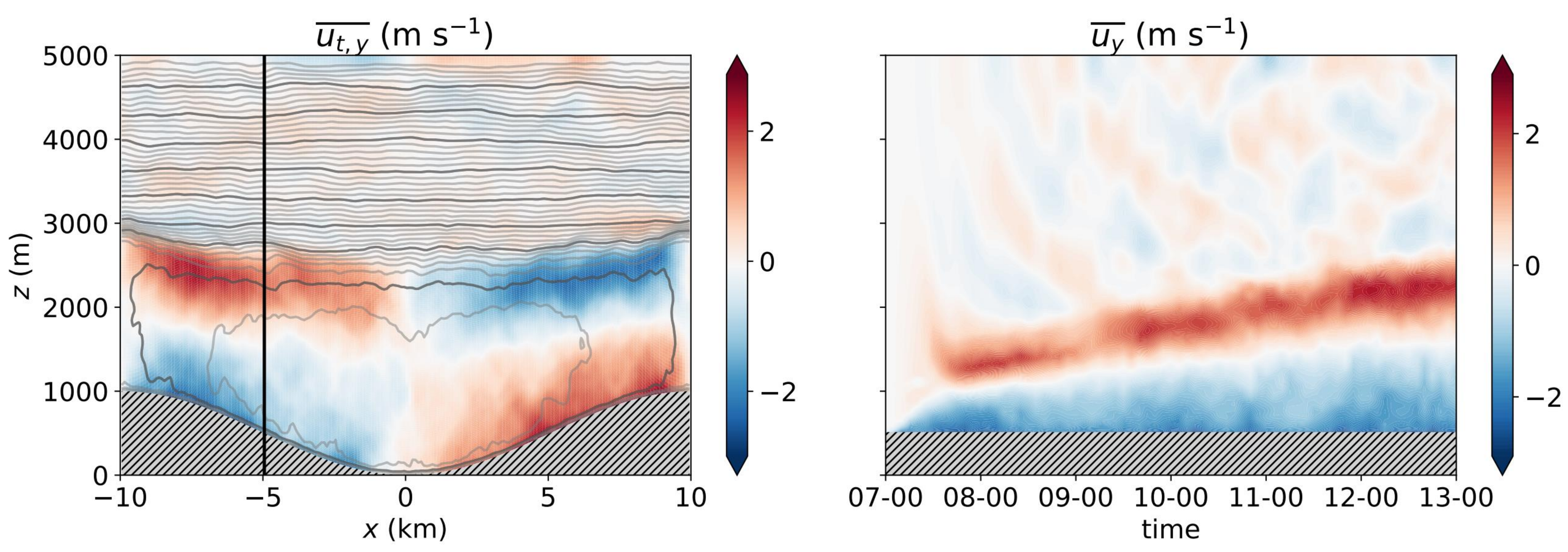
Figure: *Time-height sections of covariances between synthetic zonal wind observations (u) and vertical eddy viscosity (xkmv, left) or vertical eddy diffusivity of heat (xkhv, right).*

Motivation

- Inaccurate 1D parameterization of vertical turbulent mixing in the mountain boundary layer (MoBL) is a source of systematic model errors over mountains
- We seek to improve the accuracy of MoBL parameterizations using ensemble-based parameter estimation (PE)
- We run PE in idealized OSSEs with model error sources limited to the planetary BL parameterization

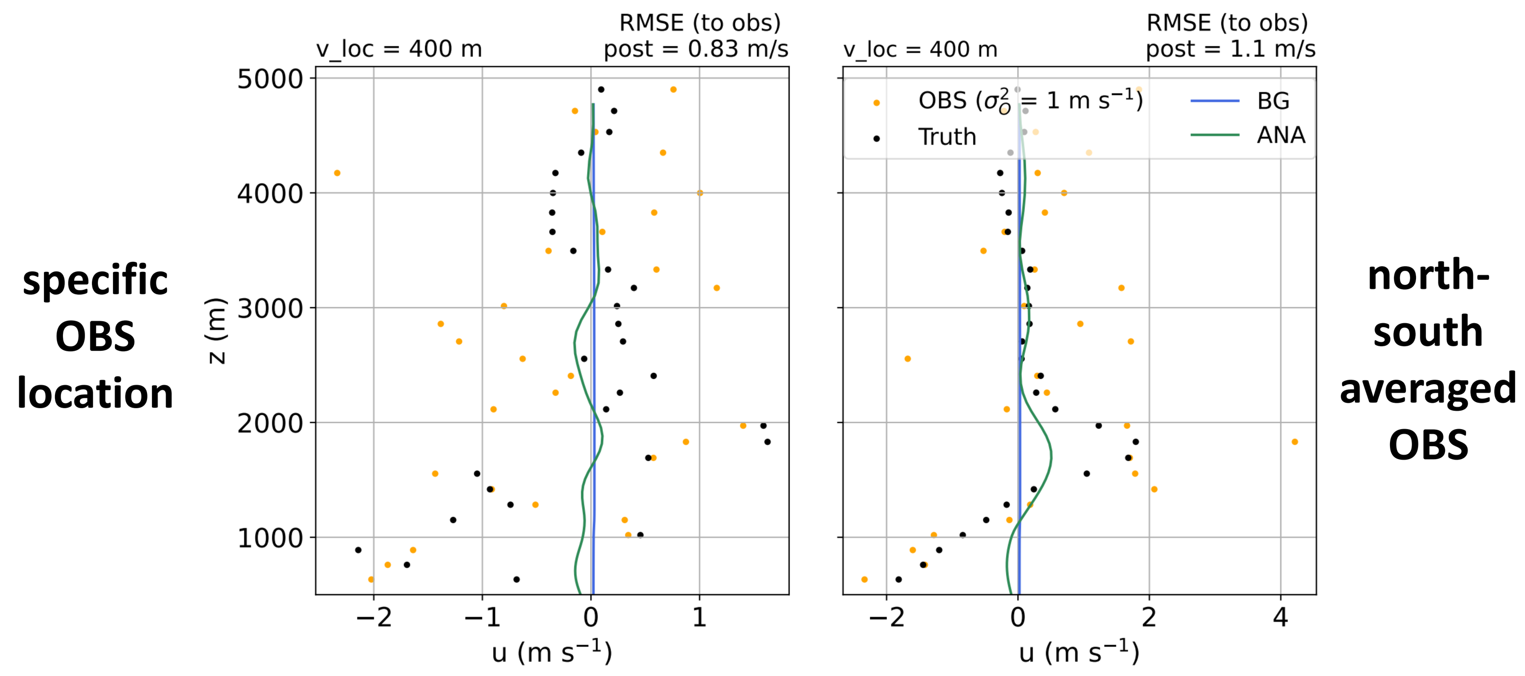
1 Nature run represents relevant dynamics in MoBL

- Idealized large-eddy simulation (LES; Δx=100 m) realized with WRF
- Idealized smooth orography (domain 4 km x 4 km)
- Spatially and temporally constant surface sensible heat flux (= 0.2 Km/s)
- LES is able to show relevant dynamics in the MoBL



3 Testing the setup with state estimation experiments

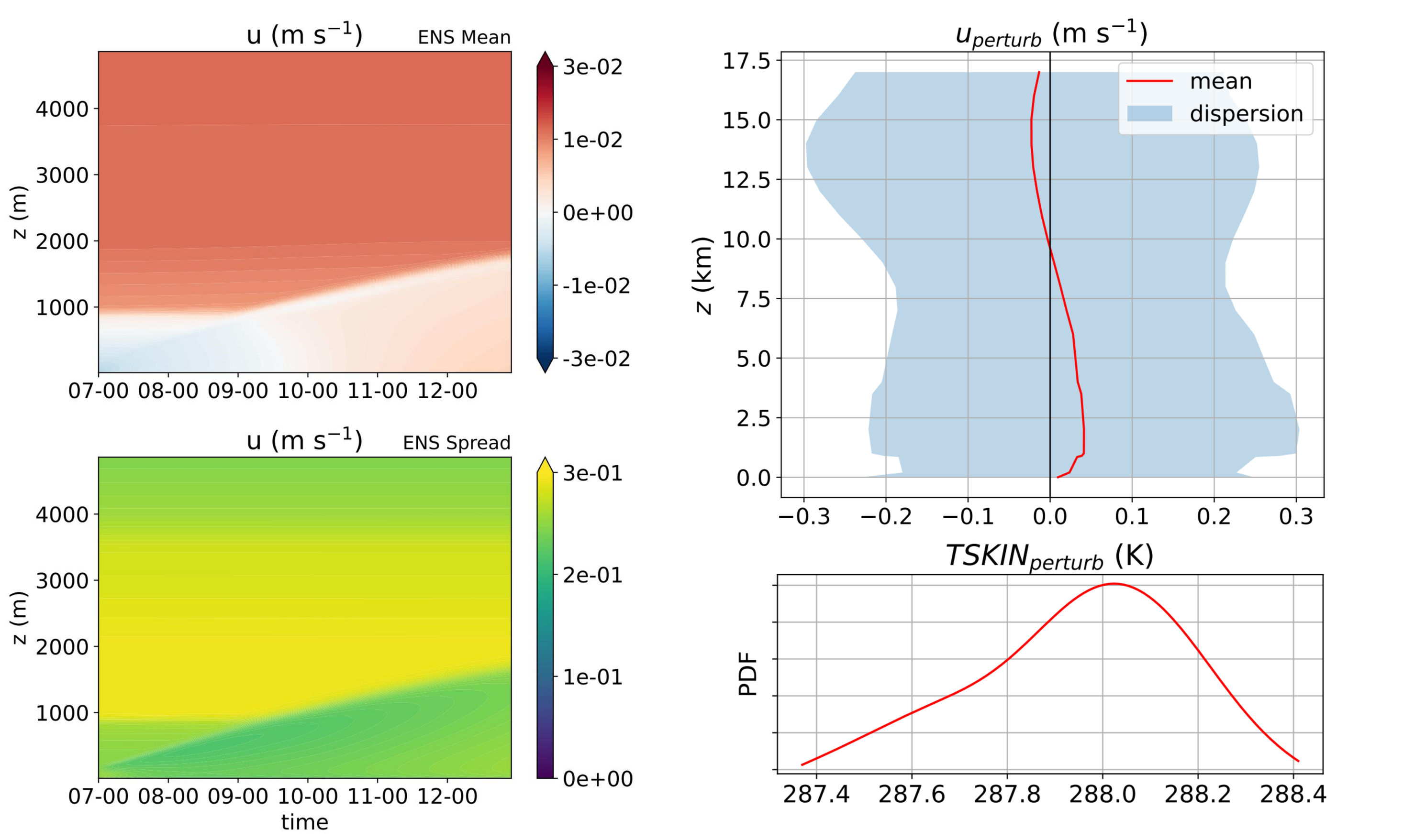
- Assimilate synthetic **u** (zonal wind) observations from the nature run
  - Surface observations
  - Profile observations ($n_{OBS,\,max}$ = 297)



1 Nature run → 2 Ensemble DA setup → 3 State estimation experiments → 4 Parameter identifiability → 5 Parameter estimation

2 Ensemble DA setup

- We use an ensemble data assimilation (EnDA) framework
- **Data Assimilation**: Ensemble Adjustment Kalman Filter (EAKF) from DART
- **Forecast Ensemble**: WRF Single-column model (SCM) ensemble (N=200)
  - **Covariance localization**: Gaspari-Cohn (**vertical** matters)
  - **Perturb** initial soundings and soil state with interpolated perturbations



4 First steps towards parameter identifiability

- Study the impact of DA on turbulence quantities (e.g., eddy viscosity)
- Test model sensitivity (with **free** ensemble runs)
  - Single-parameter ensembles (high covariance with state variables)
  - Multi-parameter ensembles (patterns of covariance distribution)
- Parameters that satisfy identifiability conditions (**observability, distinguishability, simplicity**) are further analysed

5 Open questions

- Which PBL parameters substantially **impact** the state variables?
- Which **observation types** are best suited for estimating PBL parameters?
- How can we avoid gradually reducing **parameter spread** during assimilation?
- What is necessary to perform **local** PE in the MoBL?