A mass consistent interpolation of wind measurements in complex terrain

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Objectives

Combination of micrometeorological measurements of the ADVEX experiments with terrain information

Interpolation of wind measurements between 5 towers in heterogeneous terrain

Mapping of the mass flow with a Mass Consistent Flow model on the micro-scale (< 2 km)

Appliation of the 3D wind field to advective fluxes of CO_2

Work Steps

Computation of the roughness map.

- Calculation of the displacement height d and roughness lengths z_0 from measured turbu-lence data
- Spatial distribution of d an z_0 in the model domain by Remote Sensing techniques

Derivation of wind fields

- Initial wind field: Interpolation of measured data by the use of windprofiles with rough-ness parameters for each grid point
- Optimizing the wind field for mass consistence

Background

It is the objective of the CarboEurope-IP advection activity ADVEX to calculate fluxes of mass in and out of a volume around of flux towers in heterogeneous terrain. For this purpose the setups of the CarboEurope flux-sites Renon/Ritten (It), Wetzstein (Ge) and Norunda (Swe) were extended with four additional towers around the main tower. One of the many problems in advection studies is to interpolate the measured data between the towers.

Vegetation/Roughness Parameterization

Tower Measurements

Calculation of the displacement height *d* and roughness lengths z_0 applying the Integral Turbulence Characteristics InTC to the measured turbulence data (see De Bruin & Verhoef, 1997)

***d*:** minimize the difference between measurements σ_x/x_* and theoretical InTC functions (for situations with local free convection where the influence of u_* is negligible)

$$\frac{\sigma_x}{x_*} = f\left(\frac{z_m - d}{L}\right) \quad \Rightarrow \quad d = f_d\left[\min \sum \left(\frac{\sigma_x}{x_*} - f\left(\frac{z_m - d}{L}\right)\right)^2\right]$$

x...property of the air parcel, x_*...scaled entity, σ...standard deviation, z_m...measurement height, L...Monin Obukhov length, f...InTC functions

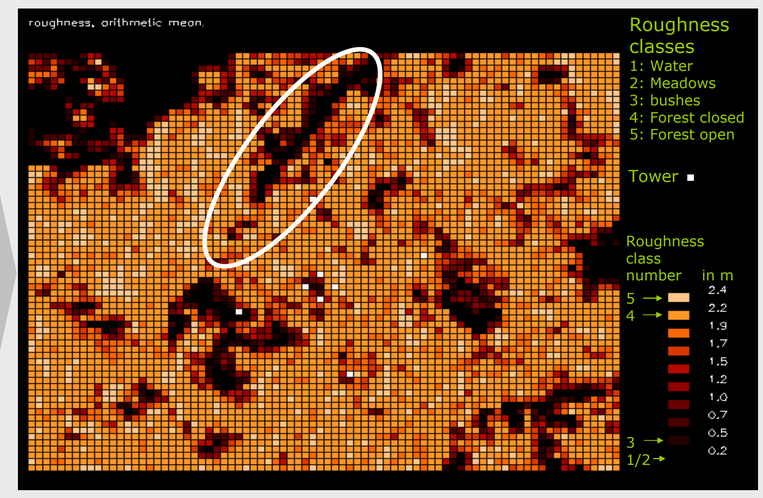
***z_0*:** from the logarithmic wind profil with the above calculated d (for near neutral situations):

$$u = \frac{u_*}{k} + ln\left(\frac{z - d}{z_0}\right) \quad \Rightarrow \quad z_0 = \frac{z - d}{\exp\left(k \, u / u_*\right)}$$

The figure below shows the used aerial view of Renon, with the roughness heights for the five towers (for 8 wind directions) calculated from measurements in 30m. The blue rectangle marks the model domain.

Remote Sensing techniques

The spatial distribution of d an z_0 in the domain was done by the use of a land-use classification deduced from the aerial view by remote sensing techniques.
z_0 of the 5 land-use classes was set accordingly to the calculations from the measurements and literature.



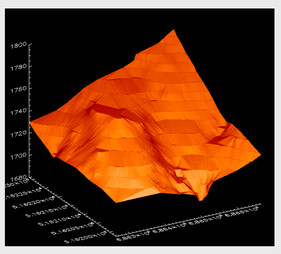
Spatial roughness length grid for the model domain, resolution is 10 m

Mass Consistent Flow Model

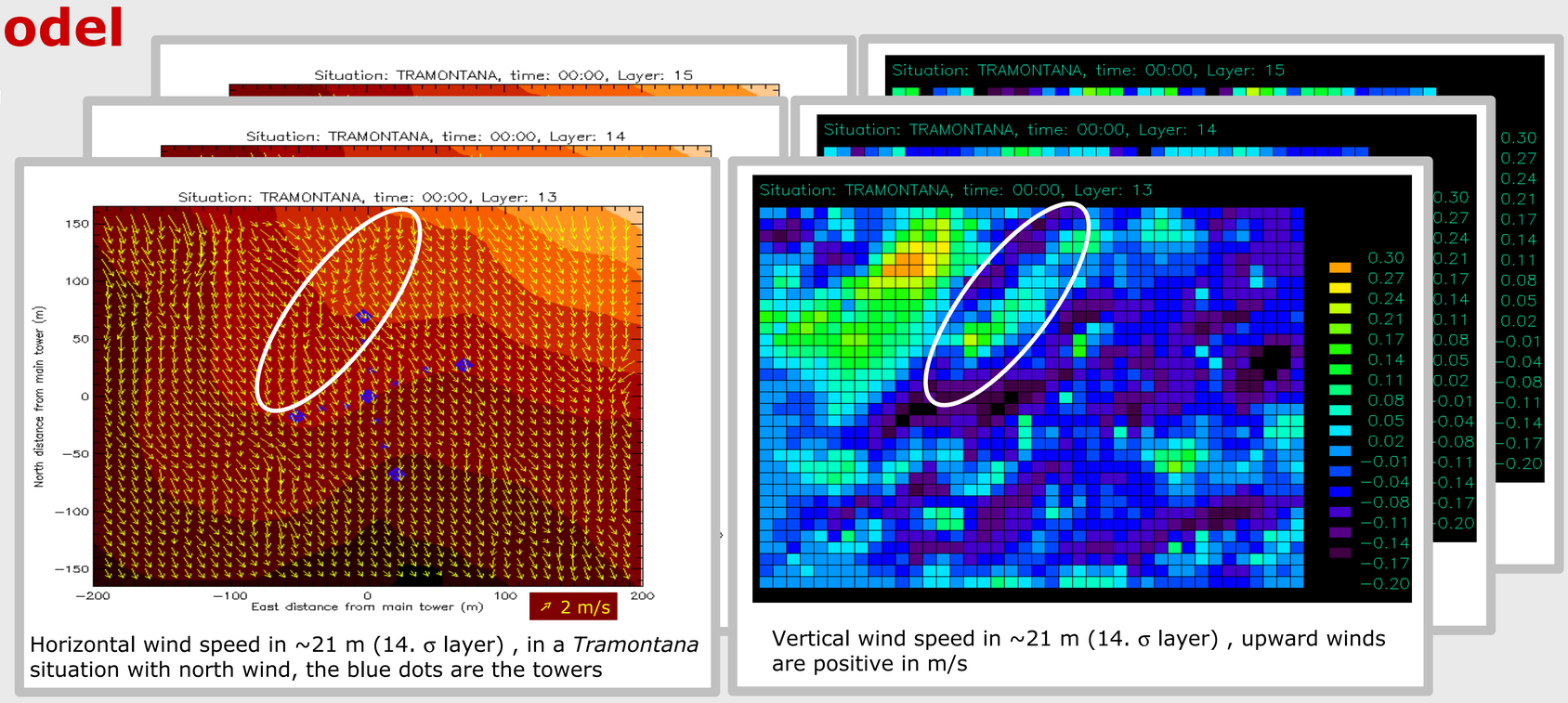
The MCF is a diagnostic flow model, which calculates a three-dimensional wind field depending on:

- Meteorological data
- Roughness
- Orography

(Digital Elevation Model) ➔



The white ellipse in the figures indicates the notable influence of the small road, also the clearing around Tower D dis-turbs the wind field. The vertical wind field is furthermore dominated by the little ridge, prominent in the elevation model. This bulge effects a wind turning in the volume outlined by the towers.



Horizontal wind speed in ~21 m (14. σ layer) , in a *Tramontana* situation with north wind, the blue dots are the towers

Vertical wind speed in ~21 m (14. σ layer) , upward winds are positive in m/s

Conclusions

- The MCF was applied to the Renon site on a domain of 400 m x 330 m with a spatial resolution of 10 m.
- The calculated wind fields are not uniform and significant vertical flows exist.
- The results show the need of a MCF for the interpolation of the wind measure-ments to include the effects caused by orography and land use.

Perspectives

➔ Improvement of the initial wind field with appropriate profile functions

➔ Implementation of flow resistances in the mass consistency flow routine

➔ ➔ Calculation of advective fluxes

Cross References

➔ ***Oral Presentation: Feigenwinter et al.:*** *ADVEX, the CarboEurope-IP advection campaigns: overview of the experi-mental activities at the CE sites in Renon, Wetzstein and Norunda*

➔ ***Poster: Montagnani et al.:*** *Application of a mass consistent model to study advective CO 2 fluxes in an alpine forest (Renon site)*

De Bruin, H.A.R.; Verhoef, A.; 1997: A new method to determine the zero-plane displacement. Bound.-Layer Meteorol., 82, 159-164.

The MCF is part of the program package WITRAK, (Michael Kerschgens et al., Uni Köln)

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