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UNIVERSITY OF TRENTO - Italy
Department of Civil, Environmental and Mechanical Engineering

Preliminary pollutant dispersion modelling with CALMET and CALPUFF over complex terrain in the Bolzano basin (IT)

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MOTIVATION

- Air quality modeling in complex terrain is challenging due to difficulties in reproducing atmospheric and dispersion processes .
- In July 2013, a new waste incinerator became operative 2 km Southwest of the city centre of Bolzano (Italy) [1].
- A modeling chain, able to provide emission-impact scenarios, is needed in the area.

AIMS

- To assess the appropriateness of the CALMET/CALPUFF [2, 3] modeling chain for application over such a complex terrain .
- To evaluate CALMET reconstruction of local meteorological fields by means of qualitative comparison with prognostic results from the WRF [4] model.
- To evaluate the discrepancies between dispersion patterns of a tracer driven with diagnostic/prognostic meteorological input.

STUDY AREA AND EXPERIMENTAL DATASET

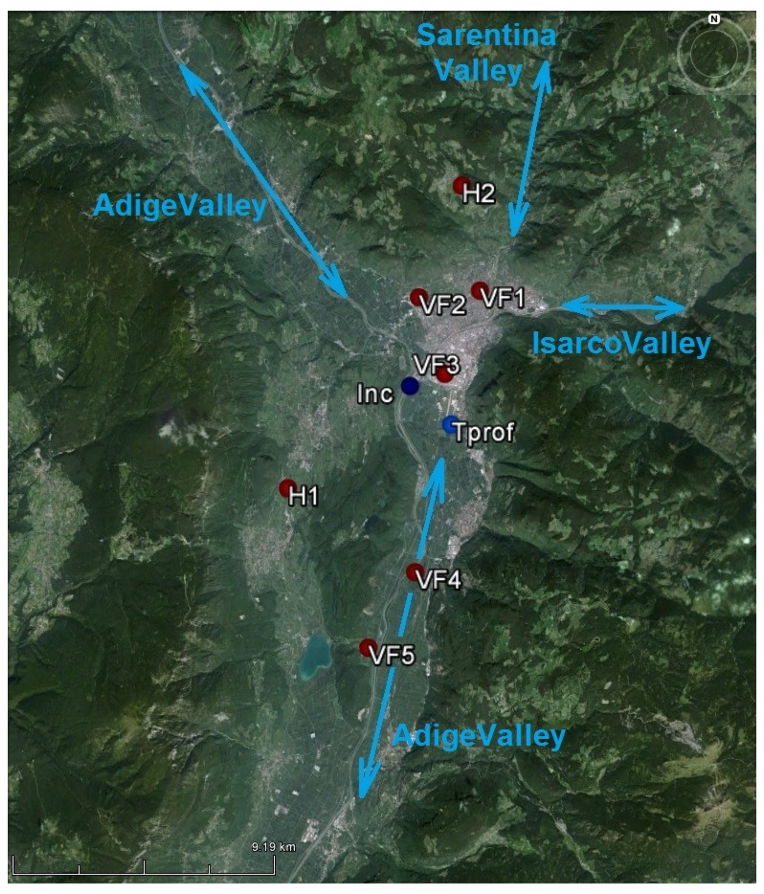

Figure 1: Bolzano basin with its tributary valleys, the incinerator plant position (Inc) and the locations of the available weather stations: the thermal profiler, Tprof, the valley floor stations, VF#, and the sidewalls stations, H#.

- Study area:
  1. Bolzano lies at 262 m a.s.l. on the floor of a wide basin at the junction of the Isarco Valley (East) and of the Sarentino Valley (North) with the Adige Valley (South and Northwest) (Fig. 1), in the North Eastern Italian Alps.
  2. Frequent occurrence of ground-based inversions at the valley floor determines critical conditions for air quality.
- Experimental dataset from:
  1. **8 surface weather stations** (6 on the valley floor VF#, 2 along the sidewalls H#): hourly observations of temperature, wind speed and direction, relative humidity and atmospheric pressure;
  2. **thermal profiler** (Tprof): temperature observations at 50-m intervals, up to 1000 m a.g.l., measured in the centre of the Adige Valley;
  3. **SODAR instrumentation** (Inc): observations of wind speed and direction at 10-m intervals, up to 340 m a.g.l., measured at the incinerator plant.

CASE STUDY

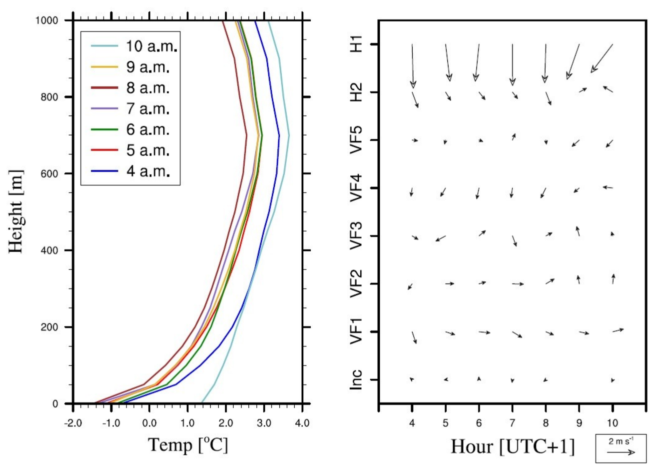

Figure 2: Observations of the vertical temperature profile (from Tprof in Fig. 1) up to 1000 m a.g.l. (left) and wind speed and direction measured at 10 m a.g.l. at various weather stations (right).

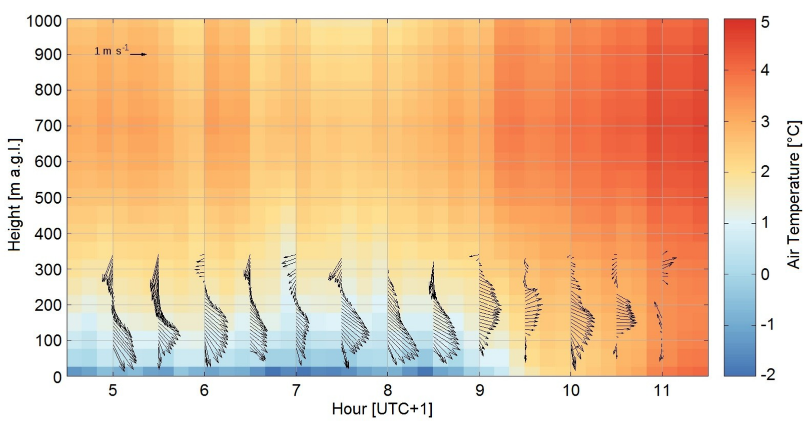

Figure 3: Observed vertical temperature and wind profiles measured from the thermal profiler and the SODAR, respectively.

- WHEN:
  1. 27th of January 2016 as reference day for the simulations;
  2. attention is focused on processes from 04 to 10 LST (UTC+1).
- METEOROLOGICAL CONDITIONS: typical wintertime conditions relevant for the stagnation of locally emitted pollutants:
  1. **strong ground-based thermal inversion**, up to 700 m above the valley floor (Fig. 2 and 3);
  2. relatively **weak wind speeds** at the valley floor (Fig. 2 and 3).
- INCINERATOR EMISSION:
  1. **release of a tracer** from the incinerator chimney from 7 to 8 LST;
  2. release concentration of 450 ppm.

WRF SIMULATIONS

- The **Weather Research and Forecasting** (WRF) model was run using **observational nudging** with the following set up:
  1. four nested domains (up to 333-m grid, 62 vertical levels);
  2. static data: 30-m DTM and 1-km landuse Modis map;
  3. YSU PBL scheme;
  4. NCEP reanalysis;
  5. hourly observational nudging of all the available measures.

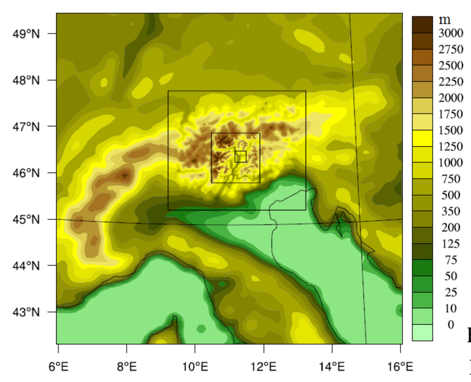

Figure 4: WRF domain nesting from Northern Italy to Bolzano basin

- WRF simulations give a detailed overview of the meteorological situation occurring on January 27th (Fig. 5):

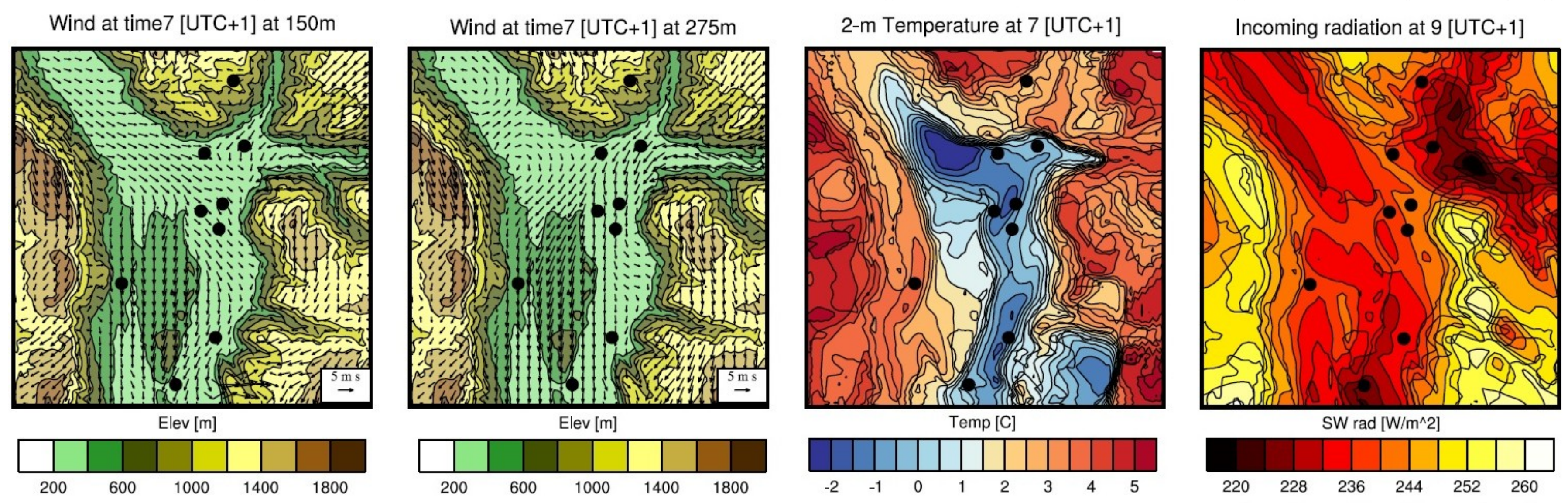

Figure 5: WRF output at different times and levels shown on the CALMET/CALPUFF domain.

CALMET SIMULATIONS

- The **CALMET model** was run as follows:
  1. 20x20 km² domain with a horizontal resolution of 200 m and 11 vertical levels;
  2. only data from measurements are used as input to run simulations;
  3. kinematic and slope effects and Froude number adjustment are computed, and surface winds are extrapolated;
  4. small radii of influence are used accordingly with the local scale of the analysis.
- As first runs showed **deficiencies** in reproducing **ground temperature** and **incoming radiation** (Fig. 6, left) [5], these fields were externally forced into the model (Fig. 6, right):
  1. a ground temperature field varying with terrain height on the basis of hourly soundings;
  2. an incoming radiation field calculated hourly by means of GRASS GIS analysis for the given day and DTM.
- Effects of modifications:
  1. temperature modification has **NO EFFECT** on derived parameters;
  2. incoming radiation modification affects wind speed and direction near ground, along shadowed sidewalls and related **mixing heights** vary accordingly.

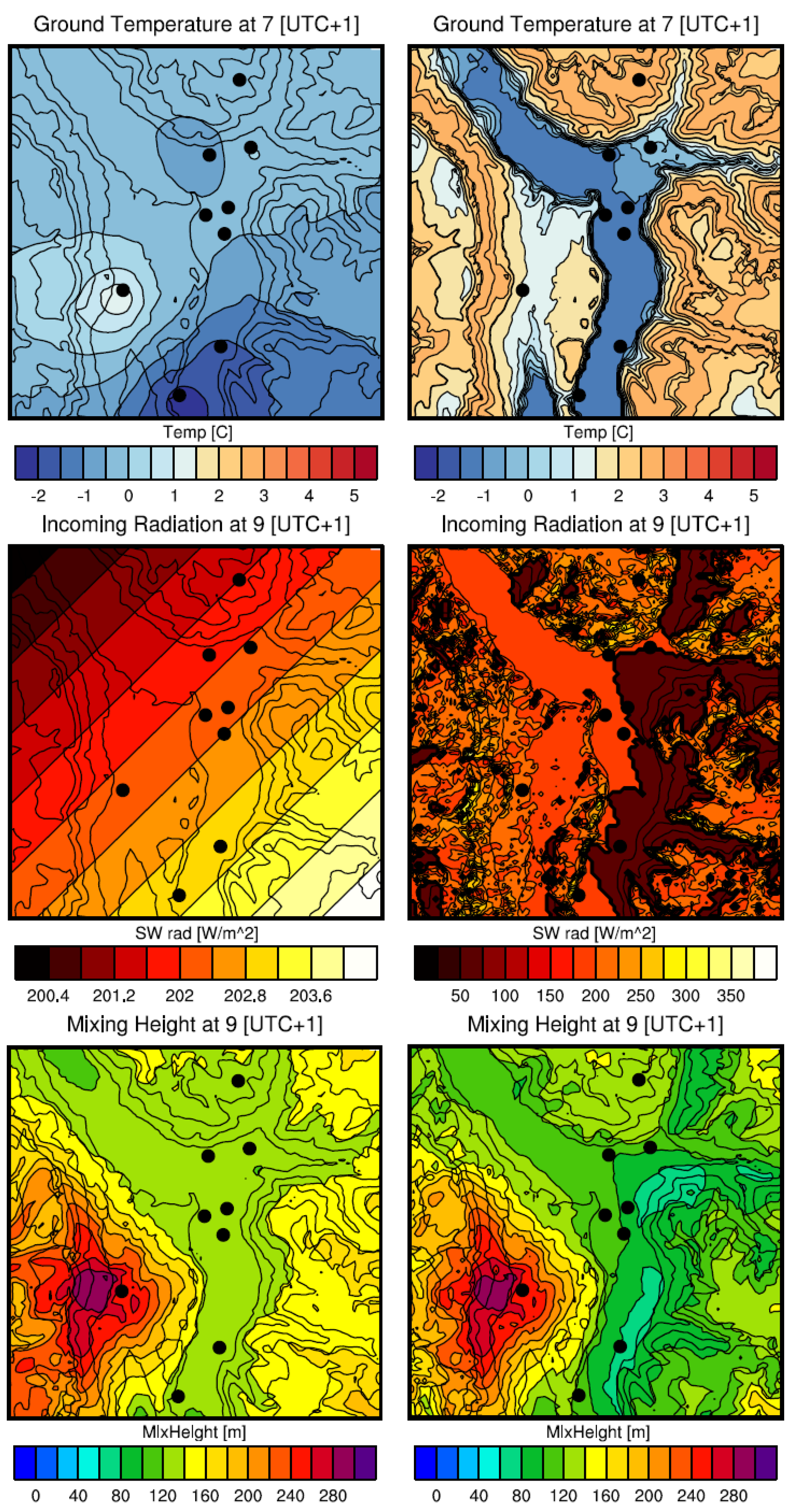

Figure 6: Near ground temperature, incoming radiation and mixing height calculated by the CALMET model in its standard configuration (left) and its modified configuration (right) where external temperature and irradiance fields are forced into the model.

CALMET RESULTS AND DISPERSION PATTERNS

- CALMET obtained wind field:
  1. wind field of the original and modified CALMET runs is essentially the same (Fig. 7) at the level where the effective release of the tracer is expected;
  2. at higher levels, CALMET is unable to identify the low-level nocturnal jet coming from the Isarco Valley.

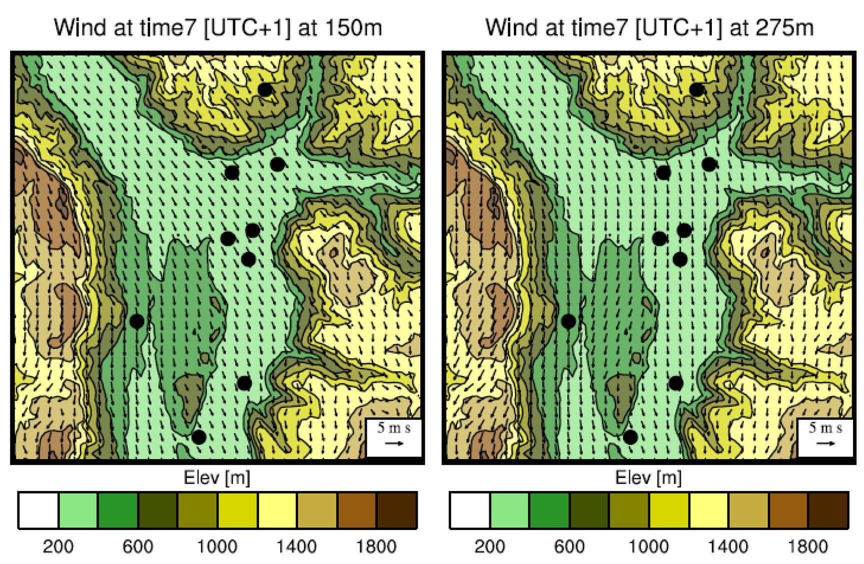

Figure 7: Wind speed and direction at release time, at two different vertical levels obtained with CALMET simulation.

- The CALPUFF model was run as follows:
  1. same domain as CALMET simulation;
  2. only one chemical species released and diffused (the tracer);
  3. two simulations are made, one with the WRF prognostic meteorological input and one with the CALMET diagnostic meteorological input.

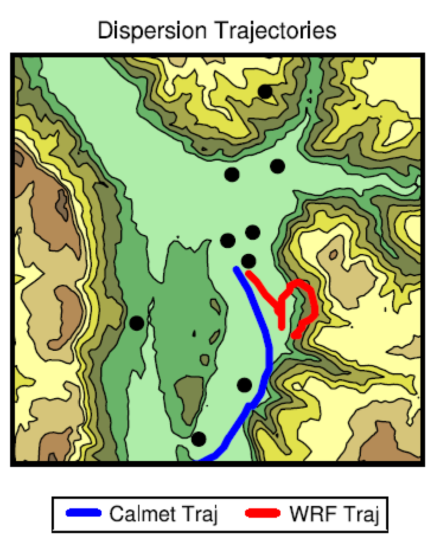

Figure 8: Trajectories of the concentration maxima at ground level, in time, calculated for the WRF/CALPUFF (prognostic) simulation and for the CALMET/CALPUFF (diagnostic) simulation.

CONCLUSIONS

- The Bolzano basin wind field is extremely complex [6].
- CALMET in diagnostic mode can not capture the whole picture of meteorol. fields over such complex terrain.
- CALMET results are non-sensitive to ground temperature field.
- CALMET near ground wind field is sensitive to changes in radiation fields and this affects mixing heights also.
- In the present case study changes in mixing height fields do not affect dispersion patterns.
- The presence of a low-level jet flowing out of the Isarco Valley and crossing the Bolzano basin introduces big uncertainties in the direction of tracer dispersion: small changes in the effective release height may lead to very different results with the WRF/CALPUFF simulation while no differences would be appreciated with the diagnostic run.

CONTACTS

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