Improving the Representation of Flow in Complex Terrain by Local-Regional Scale Model Coupling

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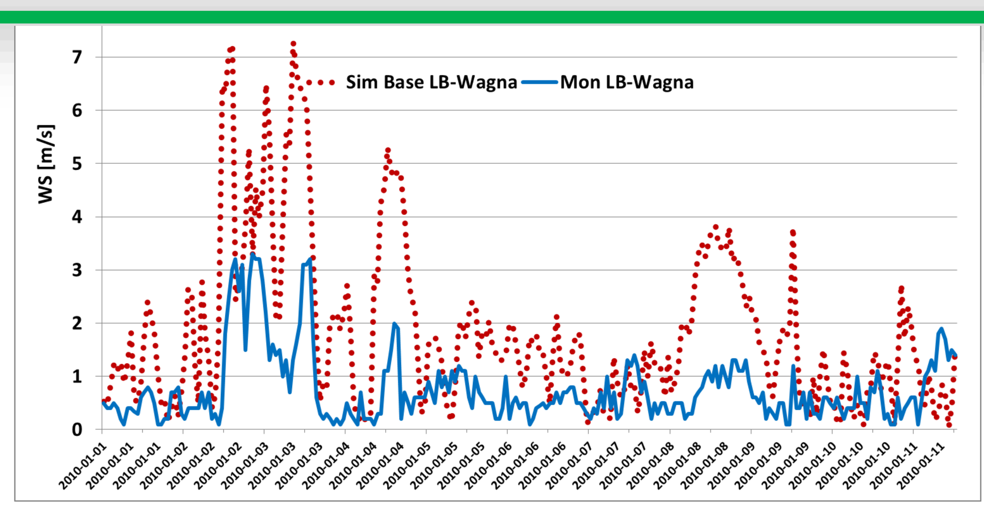
Background & Objectives

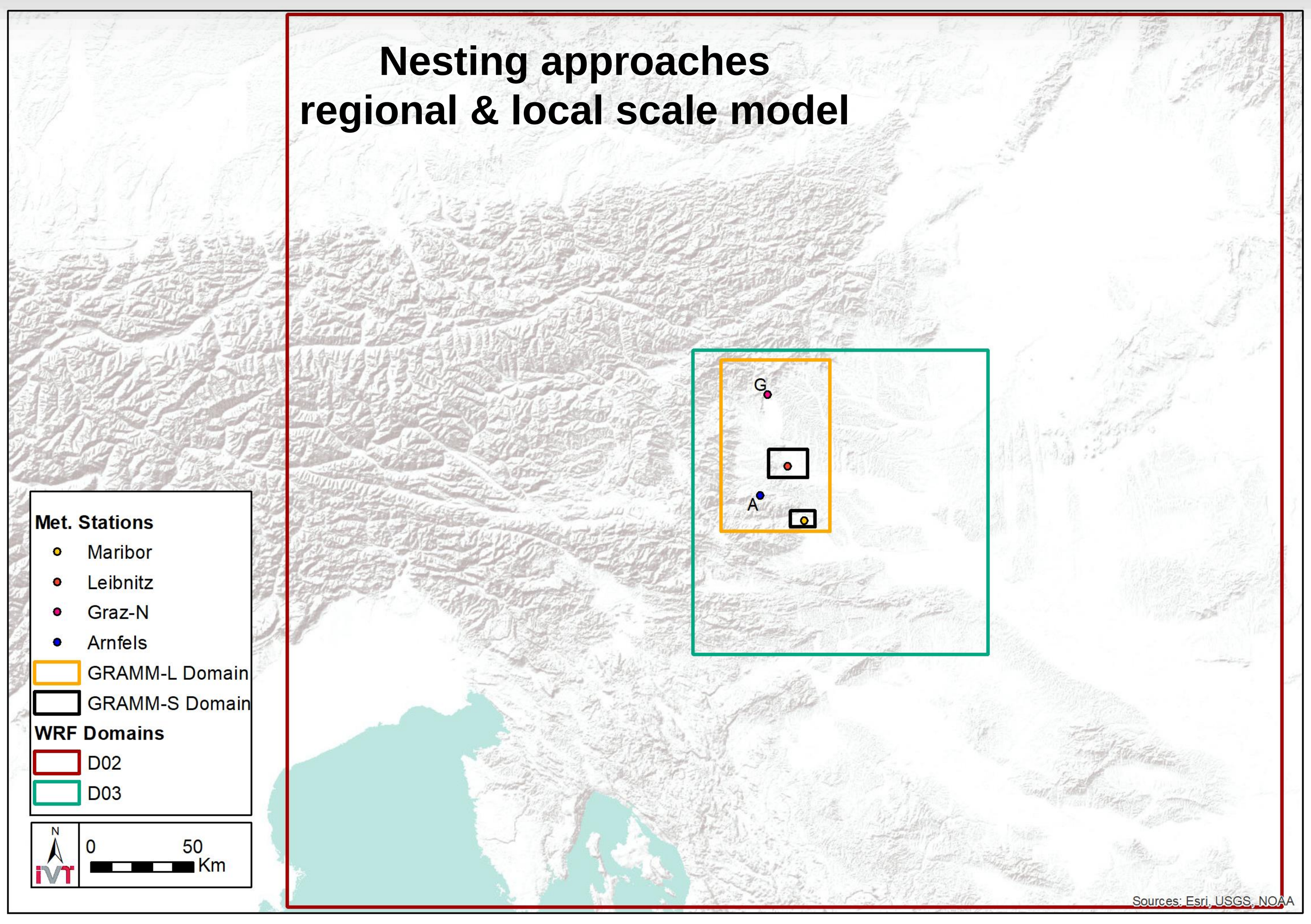
- **Low wind speed conditions & frequent inversions frequently encountered in alpine valleys & basins**, may cause → poor dispersion conditions → high air pollution levels
- **Representation of wind by NWP and regional models is poor** at **stably stratified conditions** as reported by Miglietta et al., 2012, Jiminez & Dudhia, 2012, Sandhu et al., 2013 - a wind speed (WS) bias was reported
- PMinter Uhrner et al., 2014 WRF overestimated WS by factor 2 to 2.5 in basins winter period in January 2010 (characterized by high air pollution levels)
- **Local scale model GRAMM** (GRAz Mesoscale Model, Almbauer et al., 2000) **captures low wind speed conditions well – however initialization & boundary conditions challenging**



- **Improve representation of flow in complex terrain by nesting** the **local scale** model GRAMM within **regional** WRF
  - **Nesting large & small local scale high resolution domain (Δx,y 100 m to 250 m) January 2010**

Methodology & Set-Up

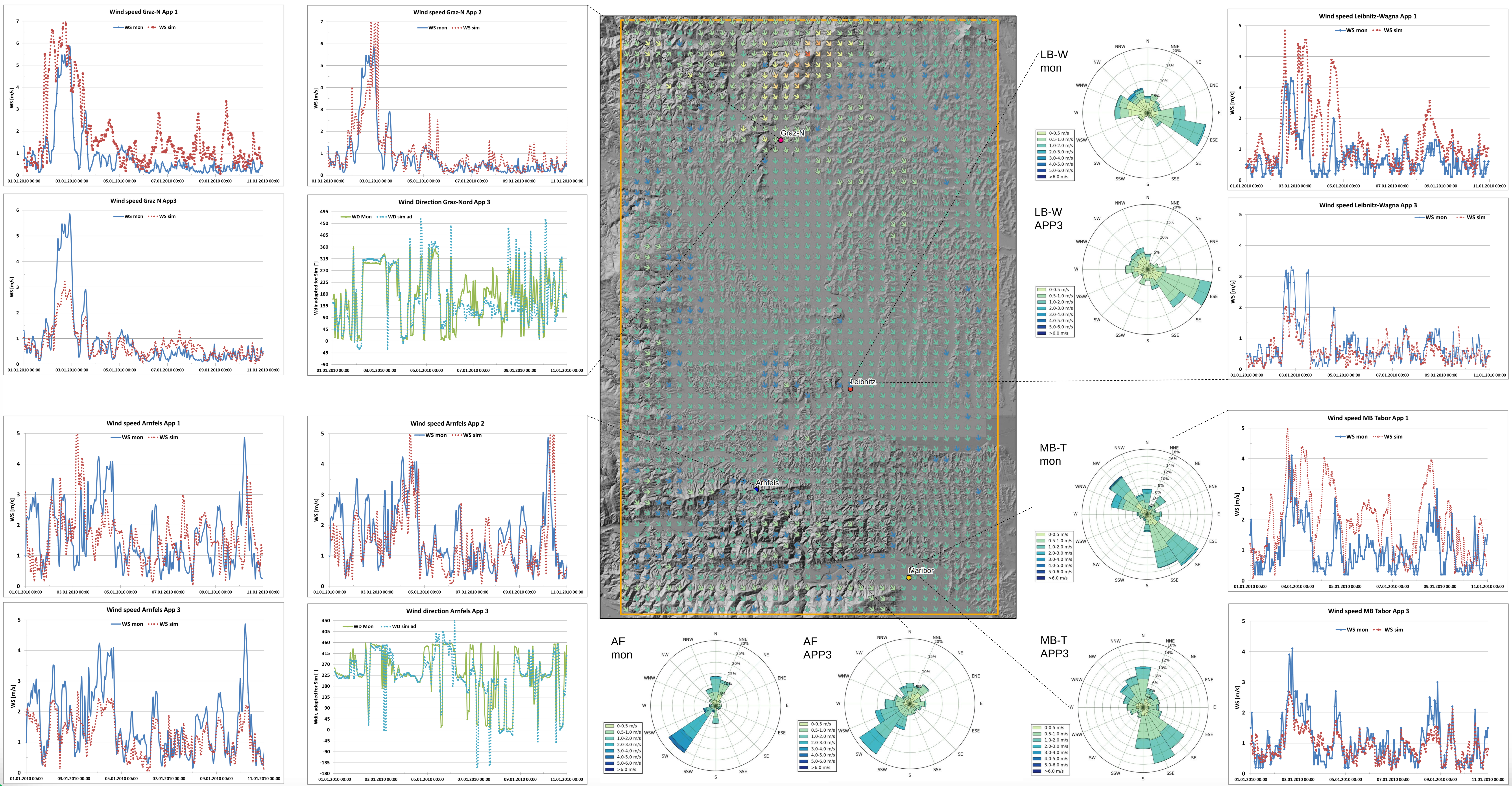
- **WRF used with multiple nesting strategy:** D01 (mainland Europe Δx,y ~ 25km, D02 (see red rectangle see Fig. right) Δx,y ~5 km, D03 Δx,y ~1 km (green rectangle)
- ECMWF ERA-Interim re-analysis → boundary conditions WRF D01 January 01 to 31, 2010
- **Regional/Local coupling interface** developed to interpolate WRF variables on GRAMM grid for initialisation & boundary conditions
- Additional initialisation scheme for **hybrid WRF-GRAMM/multiple observational surface wind forcing & temperature correction scheme** developed
- Coupled GRAMM domains 10 km x 15 km & 19.2 km x 13.8 km Δx,y 100 m & 150 m and 53 km x 83 km Δx,y 250 m orange rectangle



Overview of numerical experiments - approaches:

- **APP1: WRF computed D03 *flow, θ, q* → initialisation/b.c.'s GRAMM**
- **APP2: Adjustment of biased WRF simulated flow, by scaling WRF interpolated *u, v* using monitored 10 m winds**
- **APP3: conditional hybrid model forcing** - 10 m wind and 2 m temperature measurements used to initialize u, v, bottom up with weight function in case of significant mismatch, adjustment of WRF T-profile to correct for surface inversions

Results



Summary

Table: **R²** and slope **m** for monitored vs simulated wind speed (WS) for different experiments

	APP1 R² WS 11/25 days	APP1 m-WS 11 days	APP2 R² WS 11/25 days	APP2 m WS 11 days	APP3 R² WS 11/25 days	APP3 m WS 25 days
MB-T L	0.29 / 0.13	1.49	0.48 / 0.32	0.86	0.70 / 0.61	0.77
LB-W L	0.25 / 0.10	1.09	0.41 / 0.31	0.84	0.66 / 0.60	0.68
G-N L	0.52 / 0.35	1.35	0.65 / 0.51	0.99	0.84 / 0.72	0.65
Arnf L	0.03 / 0.03	0.73	0.39 / 0.53	0.36	0.64 / 0.66	0.64
MB-T S	0.31 / 0.13	1.56	-	-	0.55 / 0.55	0.89
LB-W S	0.20 / 0.07	1.20	-	-	0.34 / 0.27	0.68

- WRF simulations Δx,y 1 km significantly overestimated wind speeds in basins/valleys
- **WRF-GRAMM nesting reduced significantly momentum**, higher reduction in the large GRAMM domain, **improved representation wind direction**
- APP1 (forecasts possible) overestimated wind speed fair results wind direction
- APP2 (scaling, analysis mode) good results for wind speed except hill station Arnfels, poor-fair results wind direction
- **APP3** (hybrid forcing, analysis mode) **good results for wind speed & wind direction** underestimation wind speeds (by 23 to 36%)

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