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Numerical Weather Prediction at MeteoSwiss

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Current operational configuration aLMo

- **COSMO-Model Swiss implementation**
  non-hydrostatic, fully compressible
- **Prognostic variables**
  pressure, 3 wind comp., temperature, specific humidity, cloud water, cloud ice, rain, snow, turbulent kinetic energy (TKE)
- **Vertical coordinate**
  generalized terrain-following pressure based levels, Lorenz staggering
- **Horizontal coordinate**
  Arakawa-C, rotated Lat/Lon,
  mesh size: 1/16° ~ 7km
  domain: 385x325x45=5'630'625 grid points
- **Initial conditions**
  Newtonian relaxation (nudging) to conventional observations,
  intermittent cycle of 3h assimilation
- **Two 72h forecasts per day**
  boundary conditions every 3h from ECMWF global model IFS
- **Operational since 2001**
  30 Gflops sustained (25% of peak),
  12 GB memory on NEC SX-5 at the Swiss National Supercomputing Centre, CSCS
  Migration on Cray XT3 in preparation
- **Future implementations**
  Improved snow analysis using Meteosat 8 derived snow mask,
  multi-layer soil model with mosaic approach,
  measurement driven soil moisture analysis,
  new terrain following coordinate (SLEVE),
  topographic effects of radiation

aLMo domain at 7km resolution

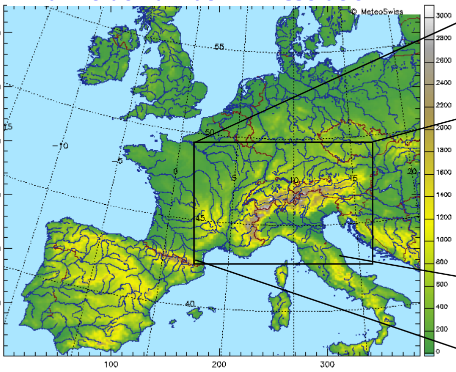


Figure 1: Operational domain of aLMo with a mesh size of ~7km showing the orography (maximum height at 3110m).

Future high resolution aLMo2

aLMo2 domain at 2.2 km resolution

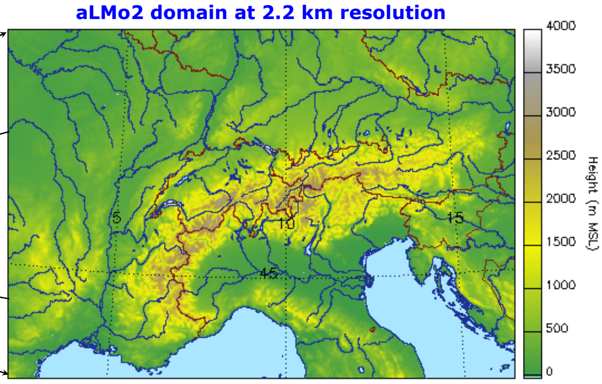


Figure 2: Foreseen domain for aLMo2 with a mesh size of ~2.2 km. The orography has a maximum height of 3950m.

- **Motivation**
  - automatic generation of local forecast products in complex topography
  - security/alarms e.g. for nuclear power plants, floods, avalanches
  - develop/keep key competence in Alpine meteorology
- **Setup**
  - numerical kernel based on 2-timelevel 3rd order Runge-Kutta
  - mesh size: 1/50°~2.2km, domain: 520 x 350 x 60 = 11'109'000 grid points
  - new schemes for graupel, shallow convection
  - rapid update cycle: 18h forecast every 3h with hourly boundaries from aLMo 7km
  - improved analysis and diagnostics of the boundary layer
  - use of radar (latent heat nudging), wind profiler, VAD, radiometers, GPS data & tomography and high resolution snow analysis using satellite data
- **Pre-operational in 2007, operational in 2008**

Validation of aLMo2 winds

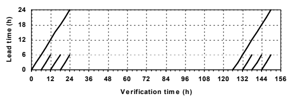
P. Kaufmann, O. Marchand

WINDBANK Experiments

WINDBANK Project	NPP Site	Start	End	Permanent Stations	Temporary Stat.
Lower Aare Valley	Beznau, Leibstadt	1995-07-01	1995-10-31	17	25
Upper Aare Valley	Mühleberg	1997-07-01	1997-10-31	20	22
Middle Aare Valley	Gösgen	1999-07-01	1999-10-31	21	22

3 x 4 month = 12 month measurement data

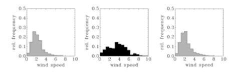
aLMo2 simulation set-up for comparison



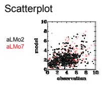
- Lead time 1 – 6 h of greatest interest
- 24 h episode for complete diurnal cycle
- Each 5th day only:
  reduction of persistent weather situations
- Following episode 6 h shift in daytime

Wind Speed: Single Station Comparisons Lägern, 868 m MSL

Histogram



Scatterplot

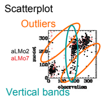


- Mountain crest station
- Distribution shifted towards low speeds
- Overestimation of low speeds
- Underestimation of high speeds

Wind Direction: Single Station Compar. Lägern, 868 m MSL

Histograms

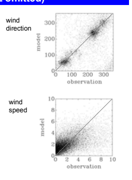
Scatterplot



- Mountain crest station
- Strong channeling by upslope wind only partially reproduced by model
- aLMo2 better than aLMo 7 km

Comparison 1999 39 stations (4 at 110 m AGL omitted)

- aLMo2 analysis versus WINDBANK measurements
- no assimilation of wind data (no station in Switzerland < 100 m MSL)
- direction quite well captured
- preferred directions due to channeling effect
- outliers far from diagonal and corners adverse for dispersion modeling
- speed overestimated for low observed speed
- underestimated for high observed speed



Total Scores

	wind direction ME	wind direction STDEV	wind direction N	wind speed ME	wind speed STDEV	wind speed N
all stations						
aLMo analysis	8.26	53.	15326	0.36	1.743	44155
aLMo2 analysis	3.23	47.	23032	0.17	1.749	64280
aLMo2 19-24h	3.53	57.	5424	0.09	1.789	16347
temporary stations						
aLMo2 analysis	4.86	45.	12115	0.43	1.295	37911
aLMo2 01-06h	4.21	48.	9125	0.39	1.286	29261

- aLMo2 analysis clearly better than aLMo (7 km) analysis
- Almost no difference between aLMo2 analysis and 6 h forecast

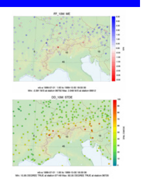
- aLMo2 analysis better ME than aLMo analysis, STD almost identical
- Almost no difference between aLMo2 analysis and 6 h forecast

Comparing Apples and Oranges?

- aLMo provides 3-d information of the atmosphere; surface wind quality is only a partial aspect for dispersion modeling suitability
- point measurements vs. cell average
- verification restricted to summer months
- "10 m wind" measurements very seldom at 10 m
- difficulty to differentiate between phase errors and other errors
- double penalty effect for small resolution

Verification with hourly SYNOP

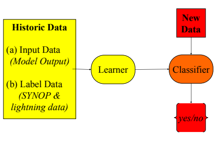
- WINDBANK experiment 1999
- Hourly SYNOPs
- Average wind speed bias (ME) 0.3 m/s
- Total standard deviation of the wind direction error (STDE) 40°



Boosting classification for thunderstorms

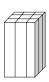
D. Perler (ETH Zurich), O. Marchand, A. Walser

Supervised Learning

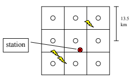


Data Sources

INPUT DATA
- for the whole year 2005
- for every full hour x:00
- for „80 stations" in Switzerland
- 3x3 profiles from aLMo



LABEL DATA
- for the times and stations
- a thunderstorm „yes" if
  - an appropriate ww-code was reported in the SYNOP
  - at least 3 lightnings were registered within 13.5 km



Physical Prerequisites for a thunderstorm

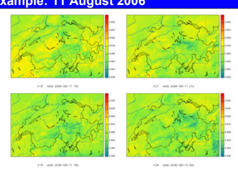
Prerequisites
- potential convective instability
- moisture
- triggers
  - orography
  - local heating
  - front
- (vertical windshear)

Consequences:
- Stability indices like CAPE are <u>not sufficient</u> to statistically detect thunderstorms
- manual choice of 51 important features
  - some direct model output
  - some computed

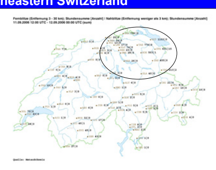
Average final scores for 5-fold cross validation for the whole year 2005

Classifier	POD	FAR	FBI	CSI	HSS
DWD (optimized for DE)	18%	94%	3.12	0.05	0.08
DWD (optimized for CH)	45%	68%	1.42	0.23	0.34
AdaBoost.M1 (DWD features)	57%	59%	1.44	0.32	0.46
AdaBoost.M1 (51 features)	72%	34%	1.10	0.52	0.67
Linear Discriminant (51 features)	57%	58%	1.43	0.32	0.46

Operational Implementation of Boosting Example: 11 August 2006



Lightning data indicate thunderstorm in northeastern Switzerland



3h aLMo sums of precipitation for the same period show no signal!