

Recent development of data assimilation in AROME in Austria

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Meteorologie und
Geodynamik

Outline

AROME
08.04.2014

- Operational settings
- Experiences with AROME data assimilation system
- Snow initialisation
- First RADAR assimilation experiments

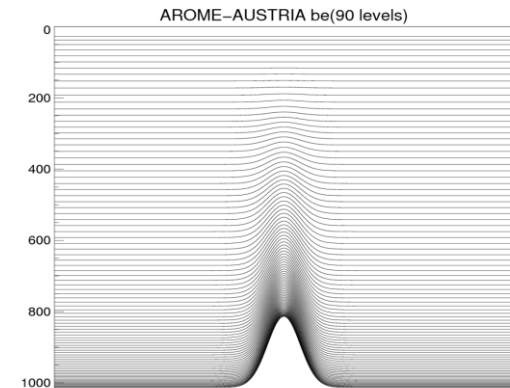
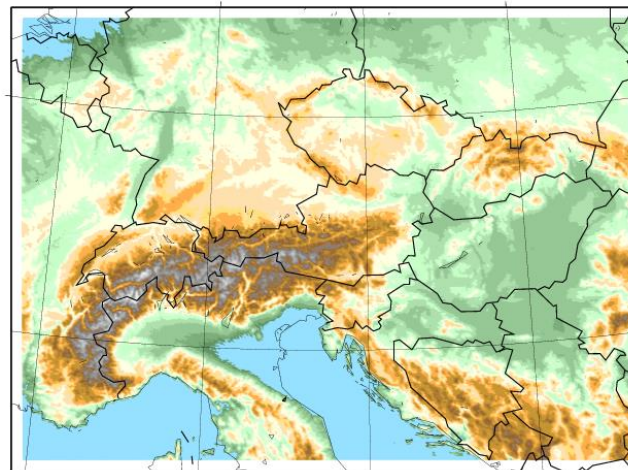
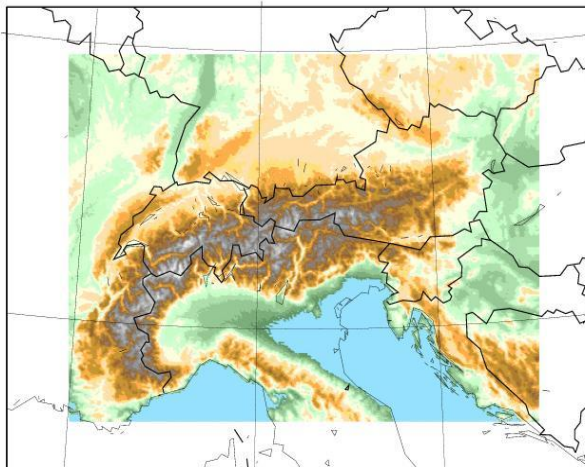
Operational system 2.5km 60L: 3D-Var + CANARI/OIMAIN

AROME

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- 8x day +30h ; 3h-assimilation cycle; cy36t1 export bf09 (OIMAIN cy36t1op2)
- B-Matrix: Ensemble method (downscaled ALADIN LAEF differences)
20110512-20110621 4member 78 diffs (20130621-20130704 16 member 100
diffs larger domain)
- LBC: IFS-lagged (6h/9h) 3 hourly
- 90L Testversion on larger domain with lower model top (~20 hPa vs 8hPa):
predictor 5/6 switched off; bug in hradpad.F90; fixed in cy38t1) AMSUA-A
ch12 & ch13 blacklisted

AROME-AUSTRIA Domain & Topography



Observations used

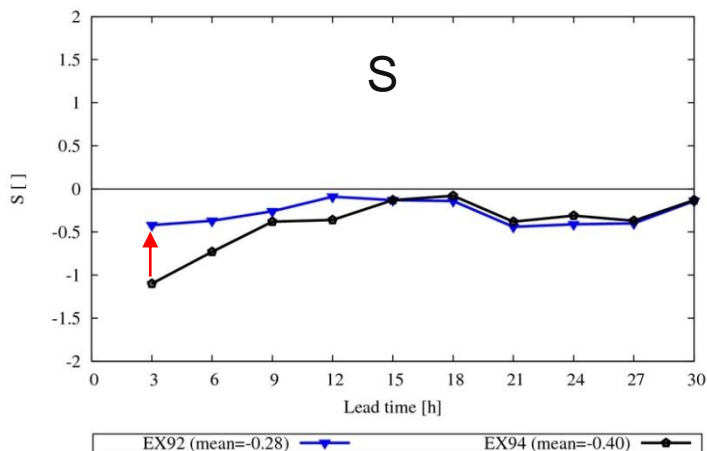
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Observation type	assimilated fields	Data source
SYNOP+TAWES	T2m,RH2m,U10m,V10m,Z	ZAMG+OPLACE
AMDAR	U,V,T	ZAMG+OPLACE
GEOWIND AMV MSG3	U,V	OPLACE
TEMP	U,V,T,Q,Z	ZAMG+OPLACE
PILOT	U,V	ZAMG
MSG3-SEVIRI	WV-radiances	OPLACE
NOAA16/18/19+MetOp-A-B AMSU-A,-B,MHS,HIRS	radiances	OPLACE
MetOp-A IASI	radiances	OPLACE+ZAMG/EUMETSAT
ASCAT 10m sea winds	U10m,V10m (25km)	ZAMG/EUMETSAT
MODIS-snow cover	snow yes/no	ENVEO-CRYOLAND

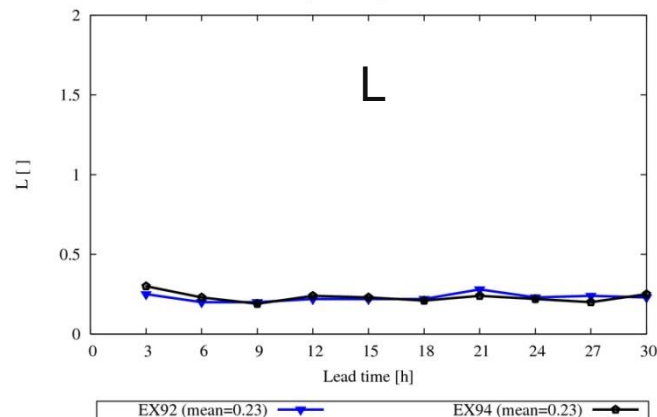
Effect of data assimilation in AROME-Austria?

AROME-downscaling IFS+ALARO soil AROME-ASSIM (OIMAIN+3D-Var)

Structure Score [S] for domain 06 (OESTERREICH_GESAMT) at 02 km resolution
rr (area mean) > 0.2 mm

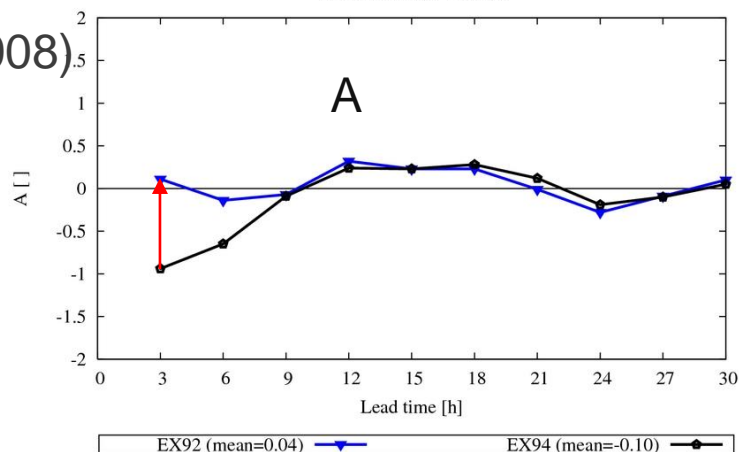


Location Score [L] for domain 06 (OESTERREICH_GESAMT) km resolution
rr (area mean) > 0.2 mm



Amplitude Score [A] for domain 06 (OESTERREICH_GESAMT) at 02 km resolution

rr (area mean) > 0.2 mm

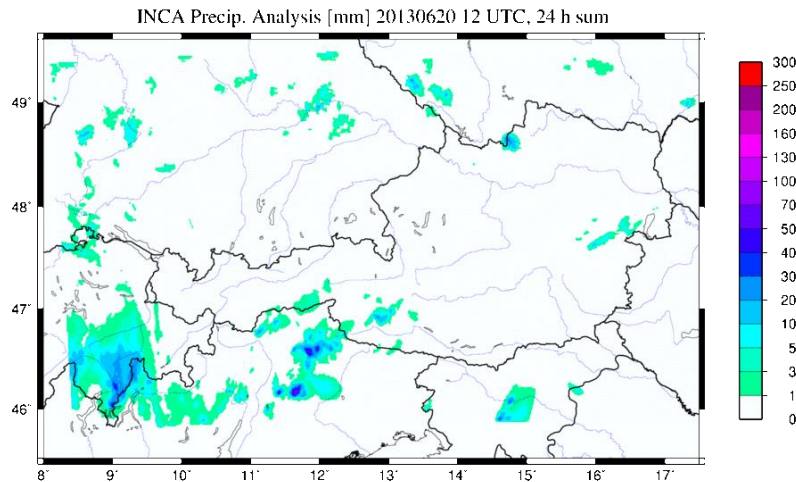


SAL-Score (Wernli et al 2008)
60 Austrian stations

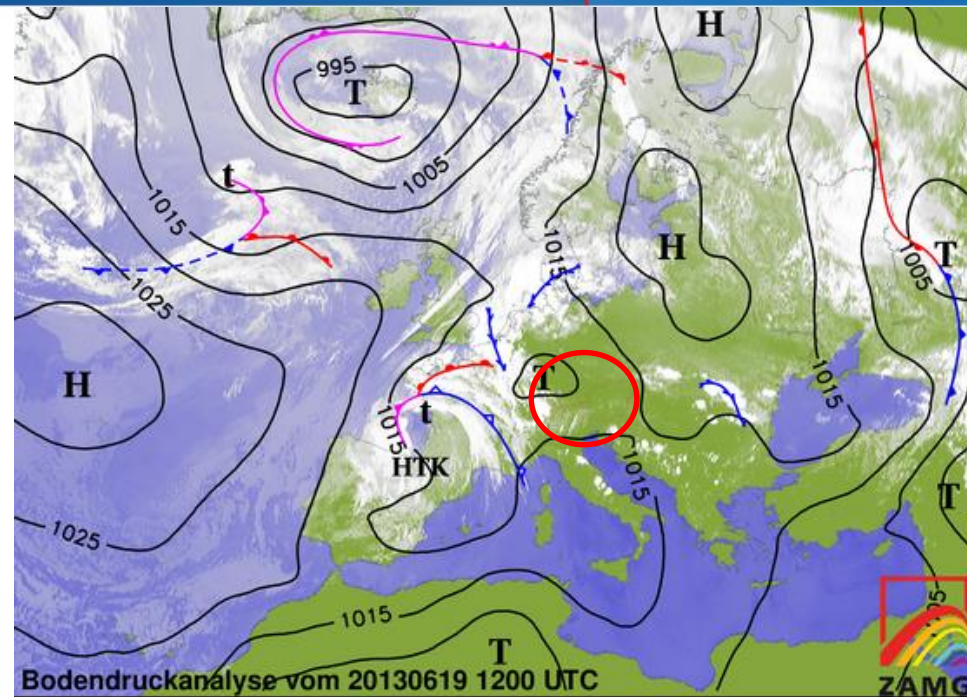
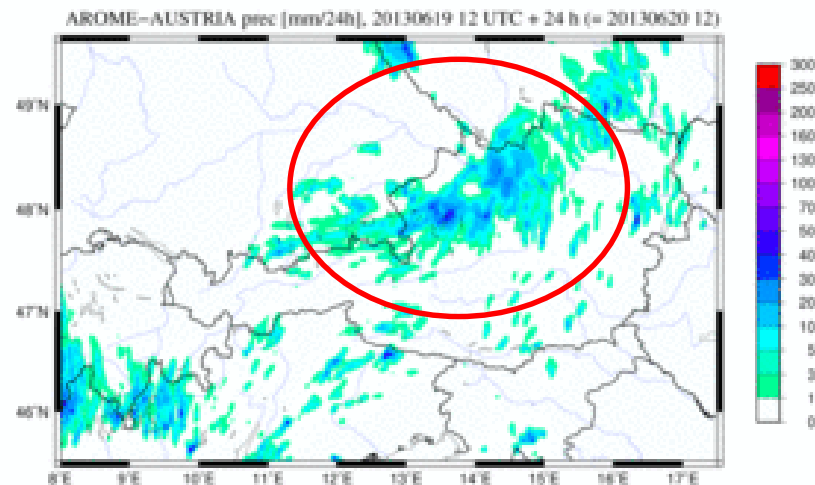
threshold: 0.2mm
spring/summer period
2011

Forecast validation: 19th June 2013 12 UTC+24h precipitation

INCA analysis (radar+rain gauges)



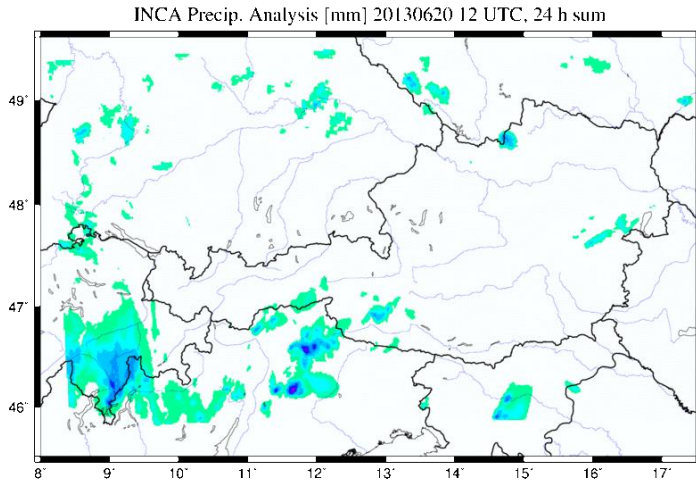
AROME-OPER



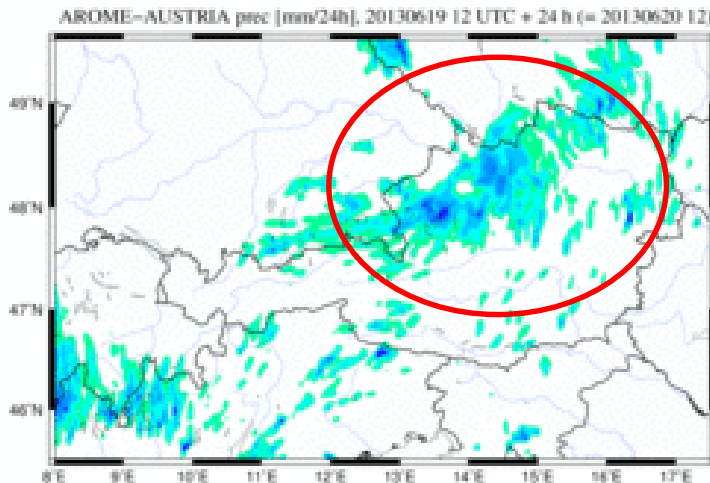
potential for improvement

Forecast validation: 19th June 2013 12 UTC+24h precipitation

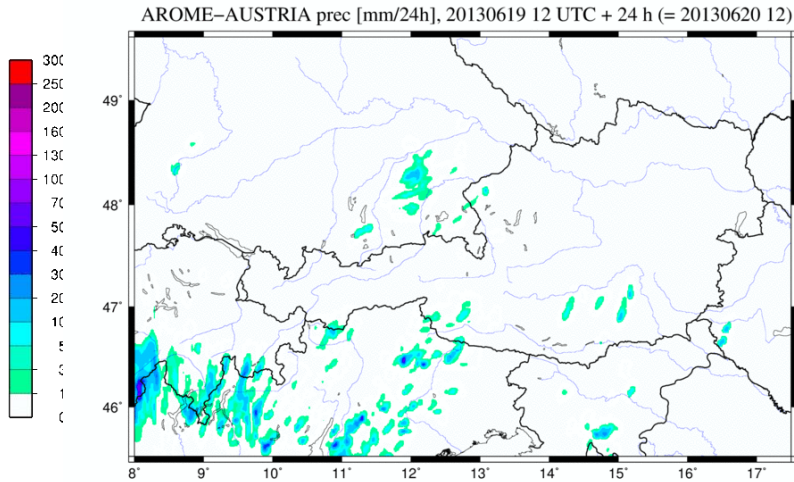
INCA analysis (radar+rain gauges)



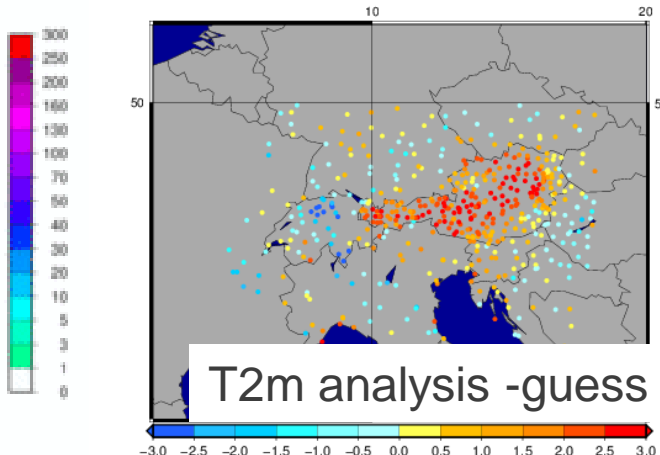
AROME-OPER



AROME without T2m/MSLP SYNOP in 3D-Var



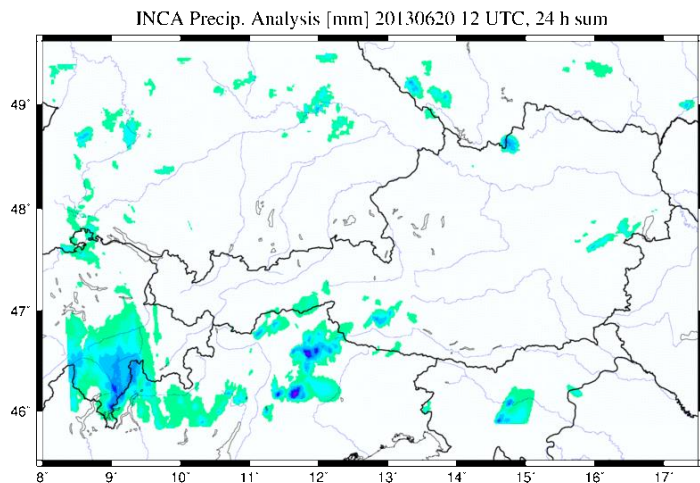
DA: ALD/3DVAR Exp: EZ06
 Date: 2013.06.19. HH: 12 UTC
 Obs: Synop Var: T2 (C) Dep: An - Guess
 Num=523 Mean=0.81 STD=1.43



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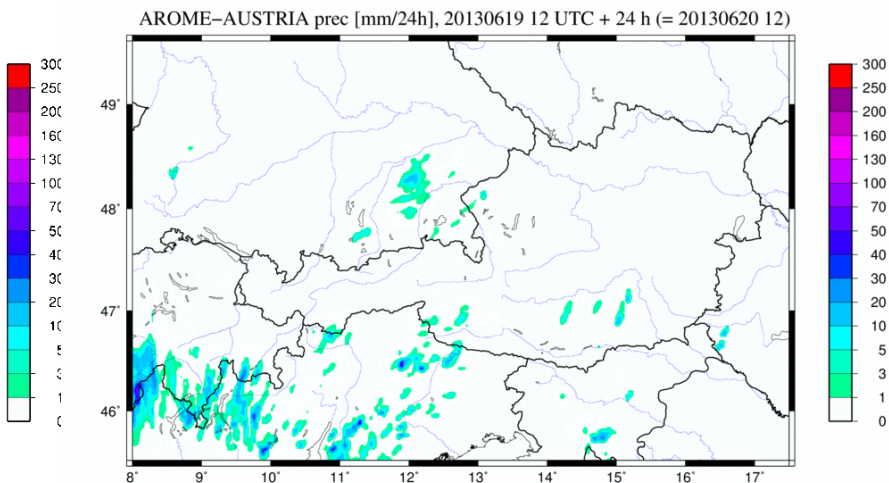
Forecast validation: 19th June 2013 12 UTC+24h precipitation

INCA analysis (radar+rain gauges)

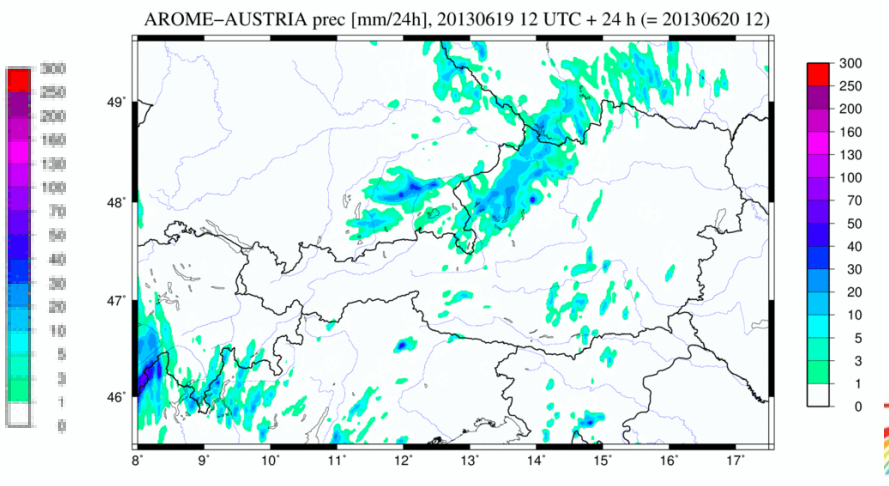


AROME-OPER

AROME without T2m/MSLP SYNOP in 3D-Var

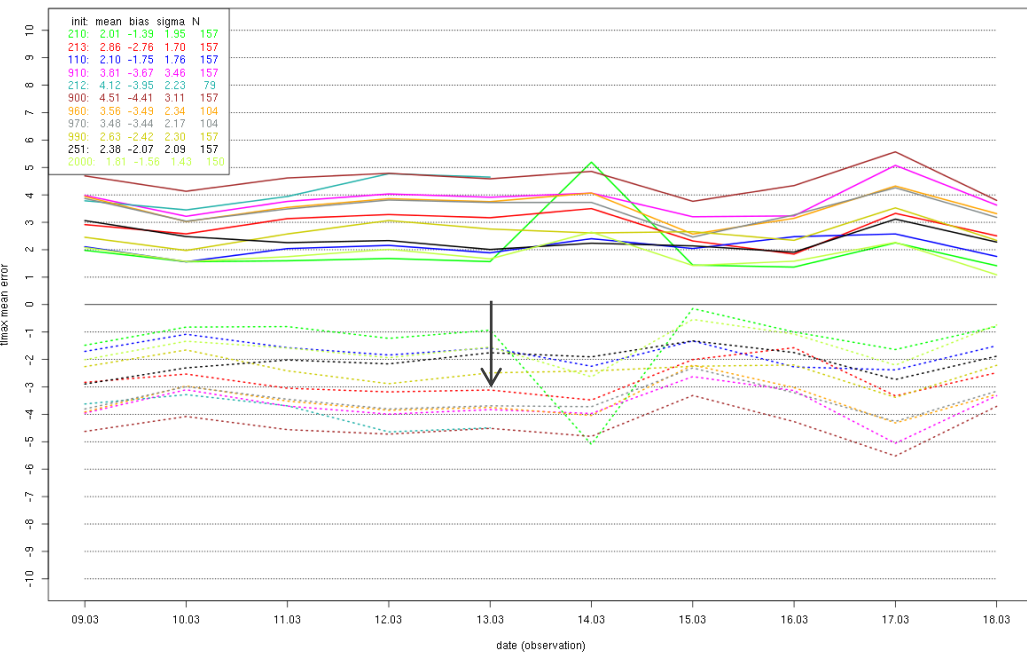


AROME thinned SYNOP

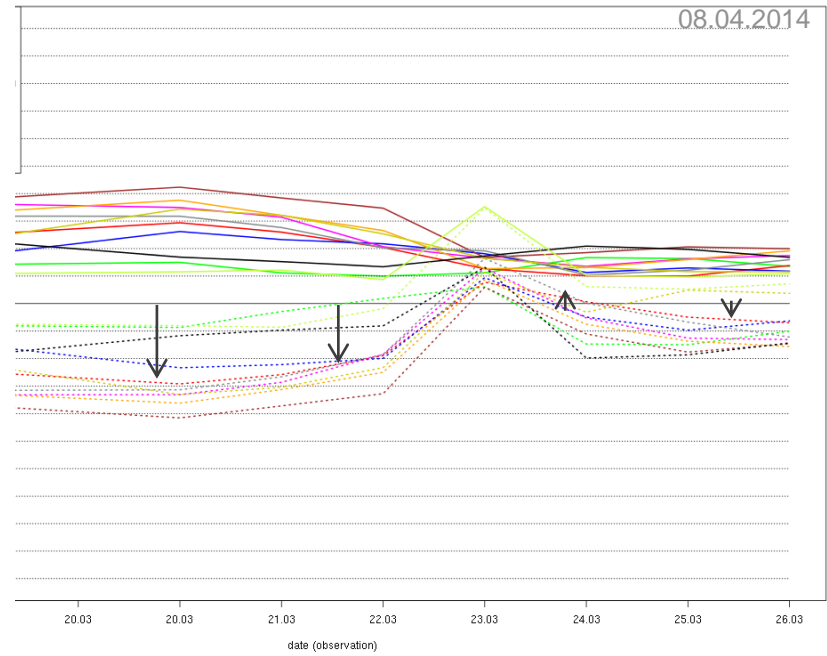


Cold Tmax bias (4K) in AROME during sunny spring period (March 2014)

t1max day-0 | all stations | modprog: multi | init: 00 | period: 20140309 - 20140318



t1max day-0 | all stations | modprog: multi | init: 00 | period: 20140317 - 20140326



AROME
ALARO
IFS GME
COSMO

Intervention:
RWPIA in OIMAIN: 0.025->0.75

Tmin OK

Too much soil ice; deep soil layer too cold

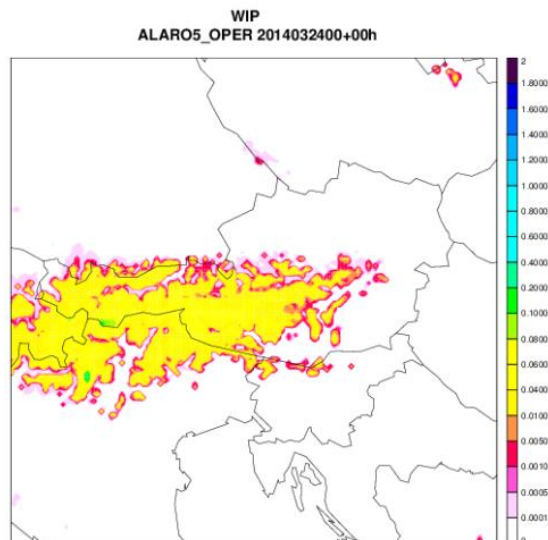
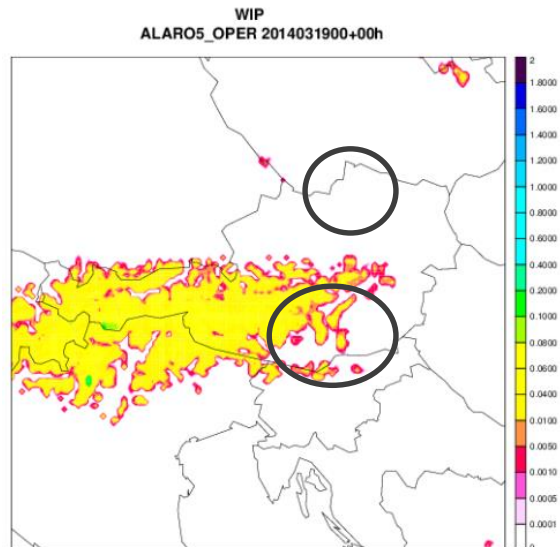


19th March 2014 00 UTC+0

24th March 2014 00 UTC+0

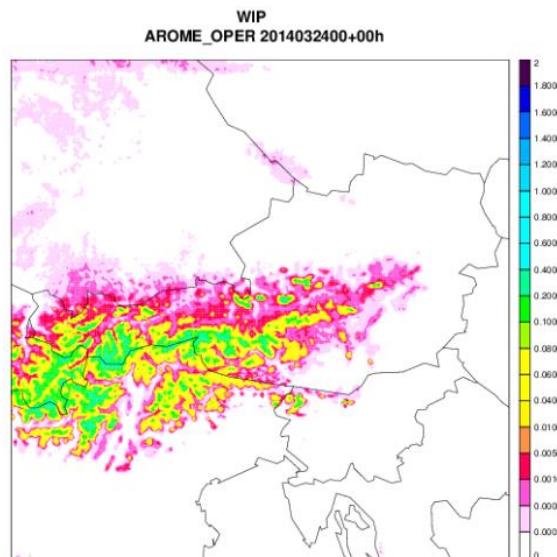
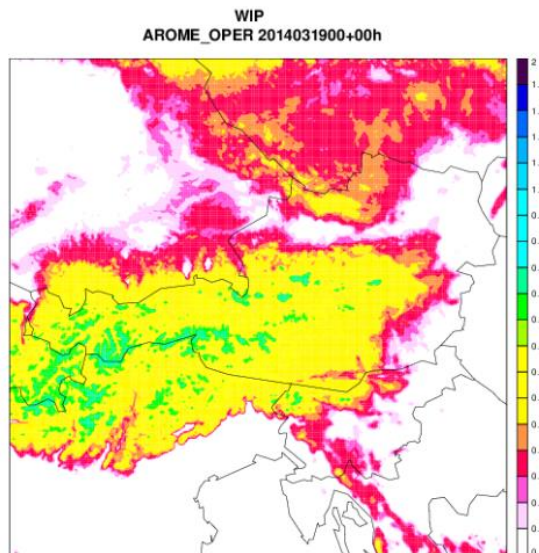
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WIP



ALARO

WIG2



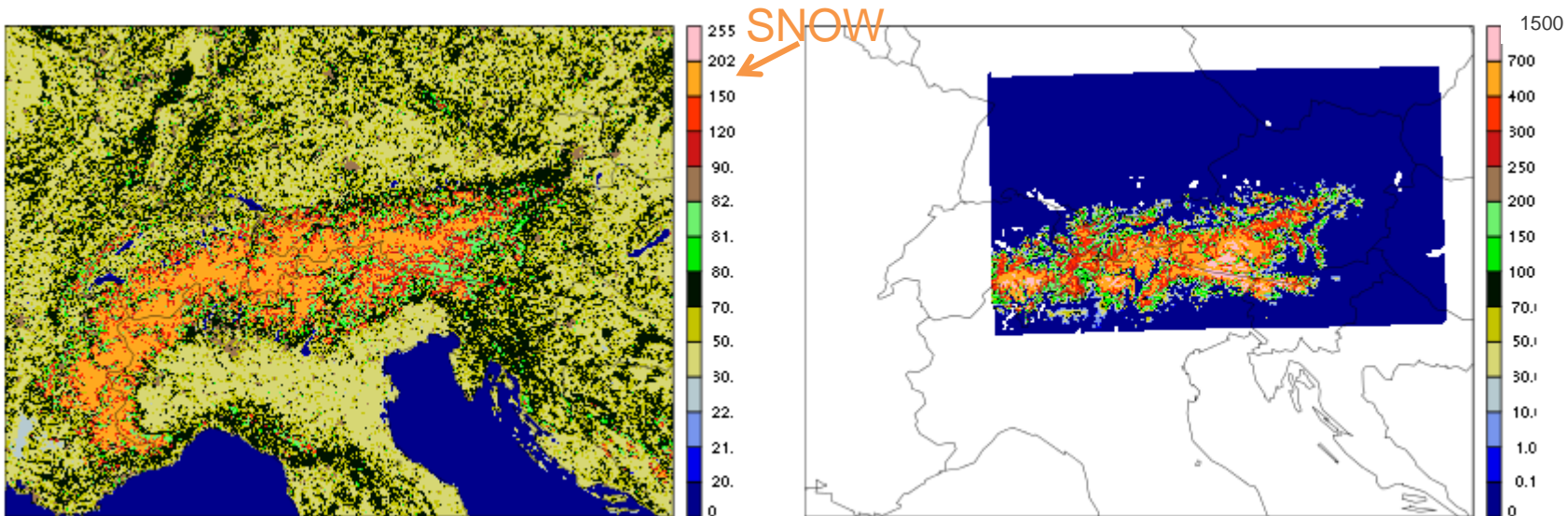
AROME

Snow initialisation: satellite MODIS + snow model Snowgrid (no real assimilation, just replacement)

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- MODIS 1km snow product: (1/day polar orbiting) from ENVEO-Cryoland (yes/no information) interpolation to AROME- domain modification in OIMAIN -> challenges: CLOUDS, snowfall between obs and analysis time (operationally used)
- SNOWGRID 2L- snow model: over Austria, based on INCA nowcasting data with high resolution orography (SRTM3+) 0.1km res.

SWE
kg/m²



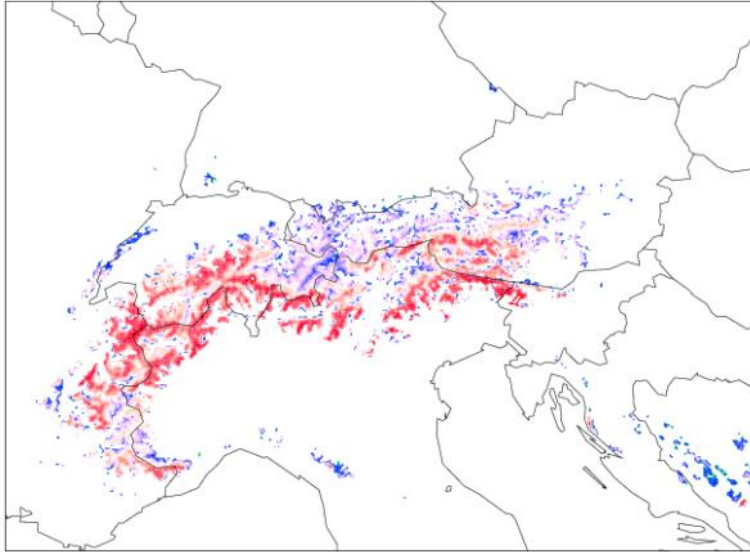
MODIS-SNOW product

SNOWGRID model on AROME grid

20140313 00 +0h

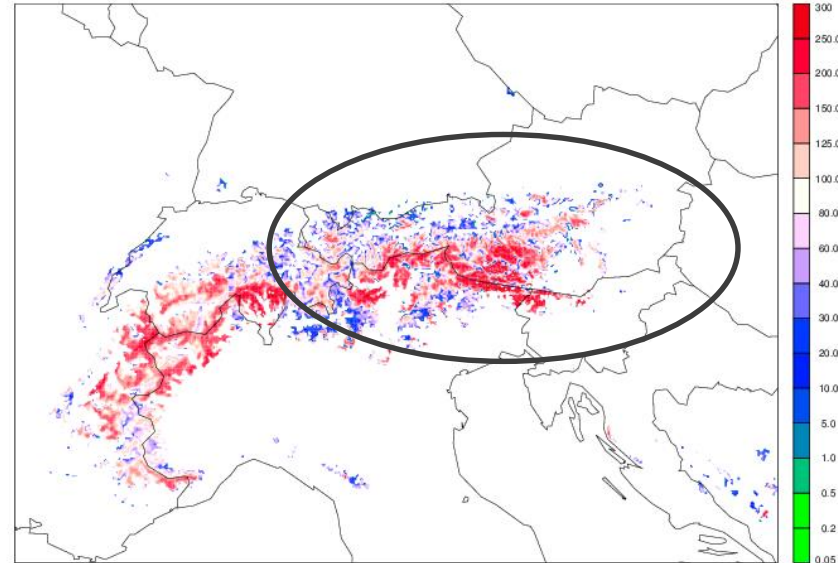
Snow initialisation

Schneehoehe AROME-REF 20140313_00 +00h



snow depth MODIS used

Schneehoehe AROME-SNOWGRID 20140313_00 +00h



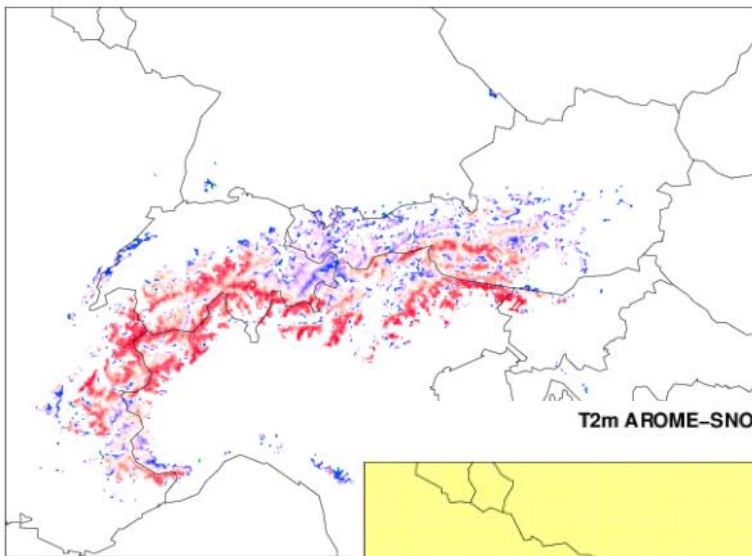
snow depth MODIS+SNOWGRID used

ROME
4.2014

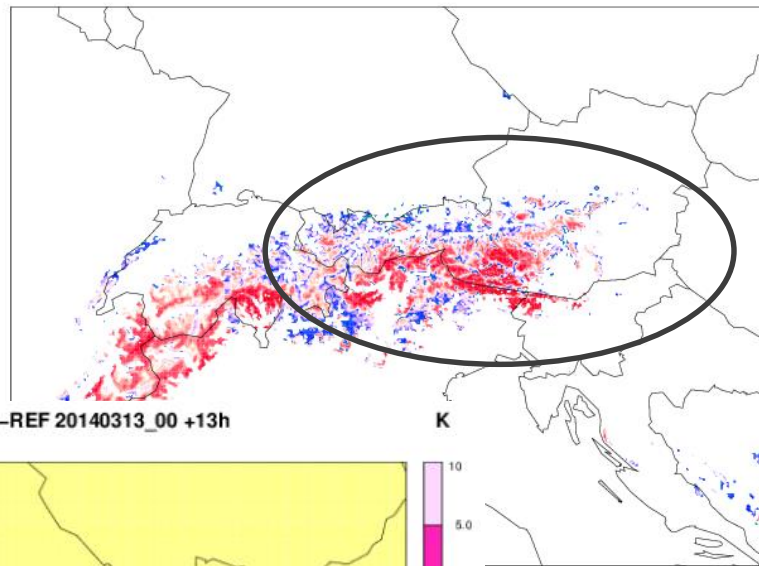
Snow initialisation

ROME
4.2014

Schneehoehe AROME-REF 20140313_00 +00h



Schneehoehe AROME-SNOWGRID 20140313_00 +00h

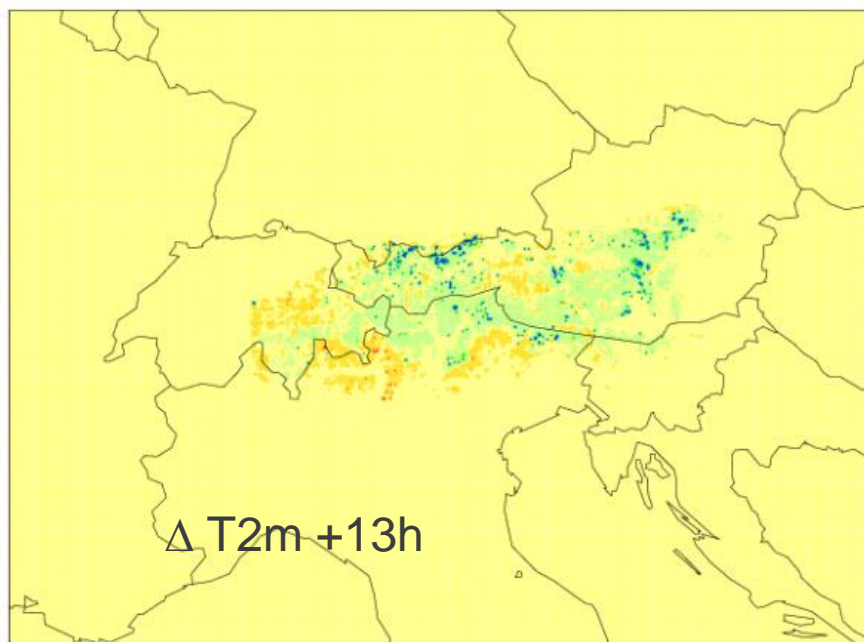


T2m AROME-SNOWGRID-REF 20140313_00 +13h

K

snow depth

NOVGRID used



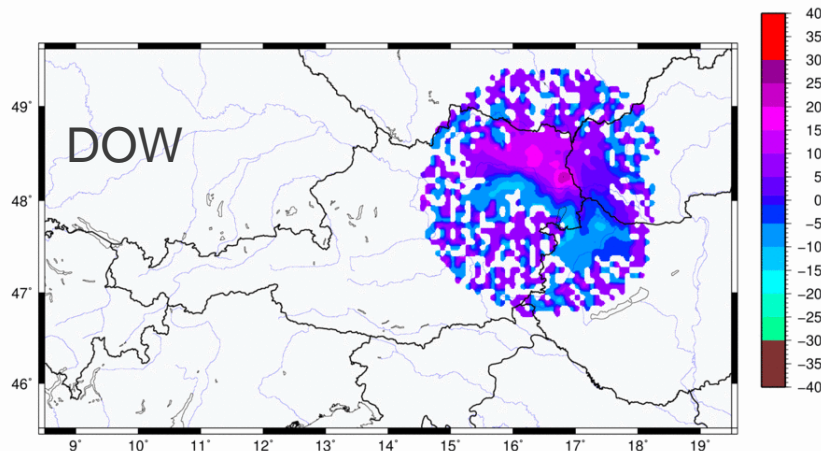
$\Delta T2m +13h$

RADAR assimilation – first steps

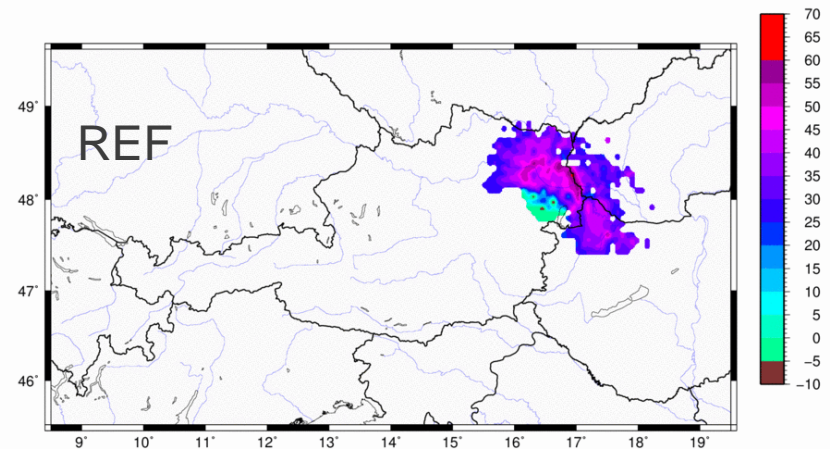
AROME
08.04.2014

- Historic period (2011/2012) of 4 Austrian radar stations (HDF5-format 16 elevations) DOW+reflectivity
- Using CONRAD (modified by T. Kovacic and local radar people) to get MF-BUFR
- No additional quality control/dialiasing so far
- Meanwhile (since 2013) all Austrian stations are dual-polarization radars (refl., VRAD, ZDR, ρ_{HV} , ϕ_{DP})

Doppler wind 20110608 00 +0h Elevation: 4.48



Reflectivity 20110608 00 +0h Elevation: 4.48

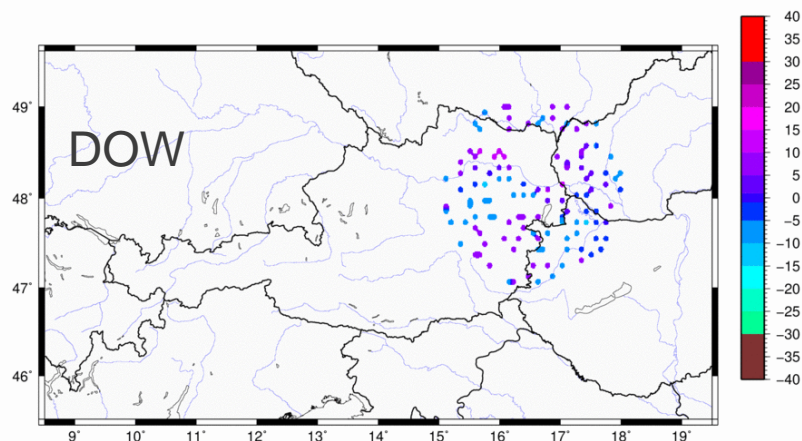


RADAR assimilation – first steps

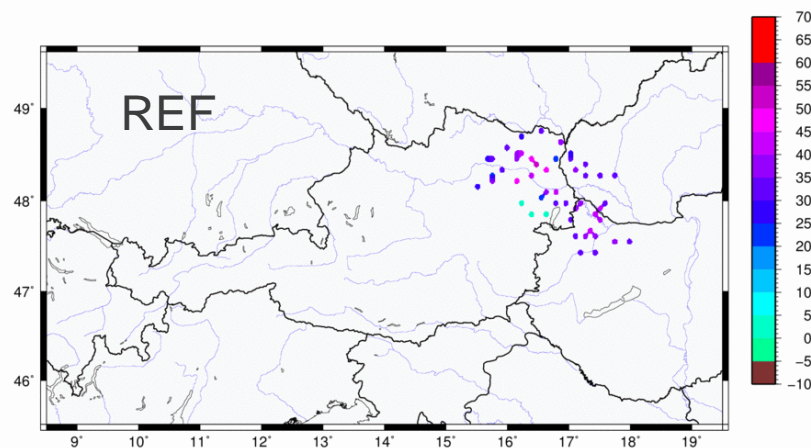
AROME
08.04.2014

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Doppler wind 20110608 00 +0h Elevation: 4.48



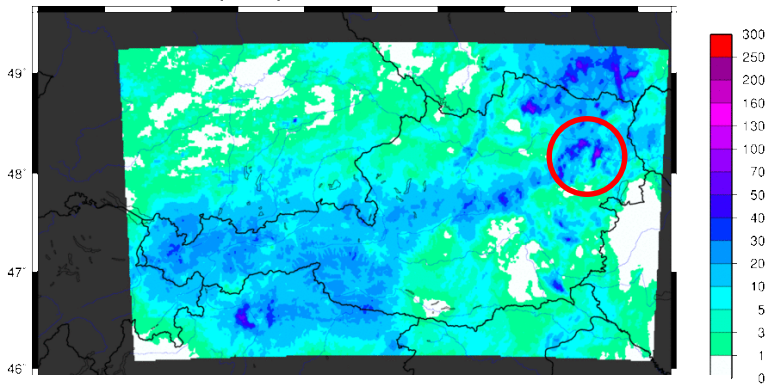
Reflectivity 20110608 00 +0h Elevation: 4.48



Case study 8th June 2011 00+24h: 24h precipitation

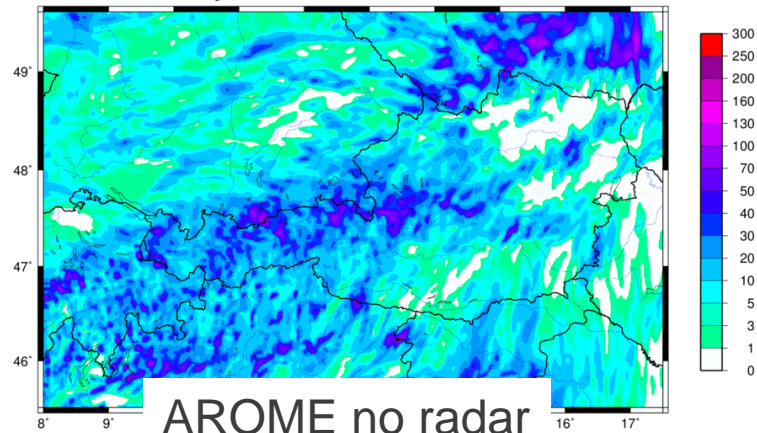
AROME
08.04.2014

INCA Precip. Analysis [mm] 20110609 00 UTC, 24 h sum



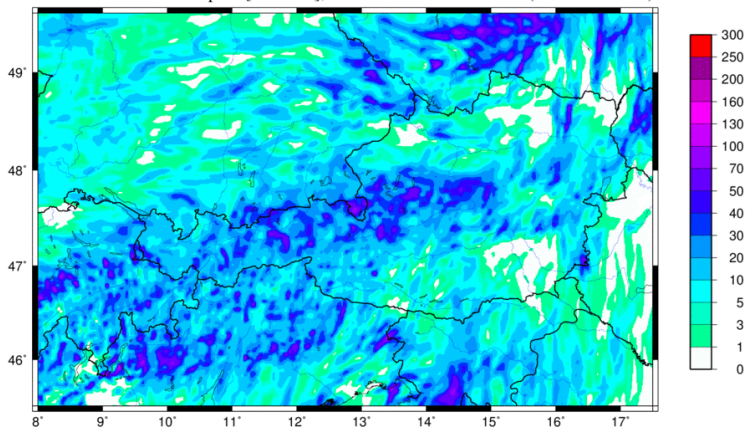
INCA 24h 82mm/12h in Vienna

AROME-AUSTRIA prec [mm/24h], 20110608 00 UTC + 24 h (= 20110609 00)

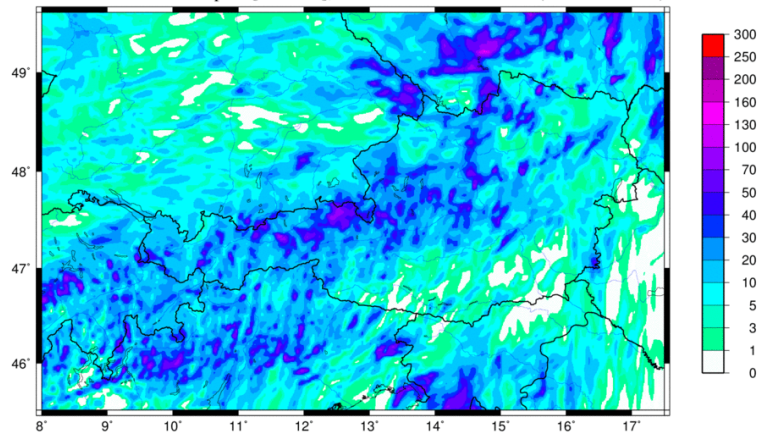


AROME + reflectivity+doppler wind

AROME-AUSTRIA prec [mm/24h], 20110608 00 UTC + 24 h (= 20110609 00)



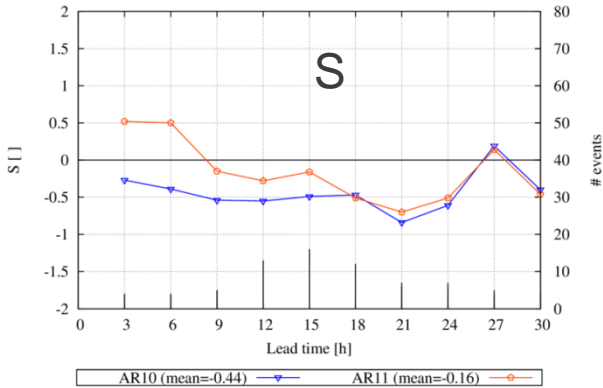
AROME + doppler wind



RADAR verification: 20110501-20110531 00 UTC

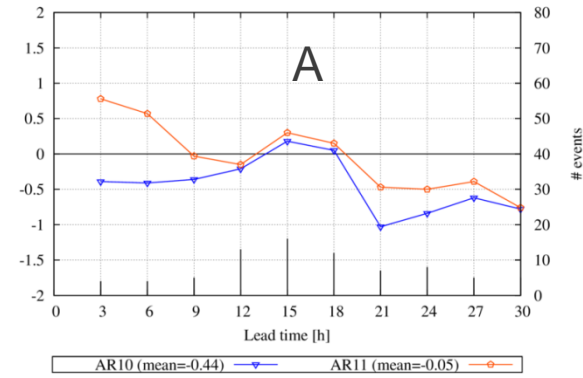
AROME

Structure Score [S] for domain 04 (NORDOSTOESTERREICH) at 02 km resolution
rr (area mean) > 0.05 mm



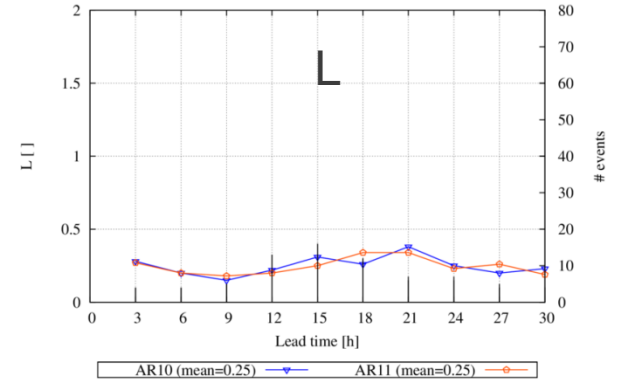
AROME+RADAR

Amplitude Score [A] for domain 04 (NORDOSTOESTERREICH) at 02 km resolution
rr (area mean) > 0.05 mm



AROME no RADAR

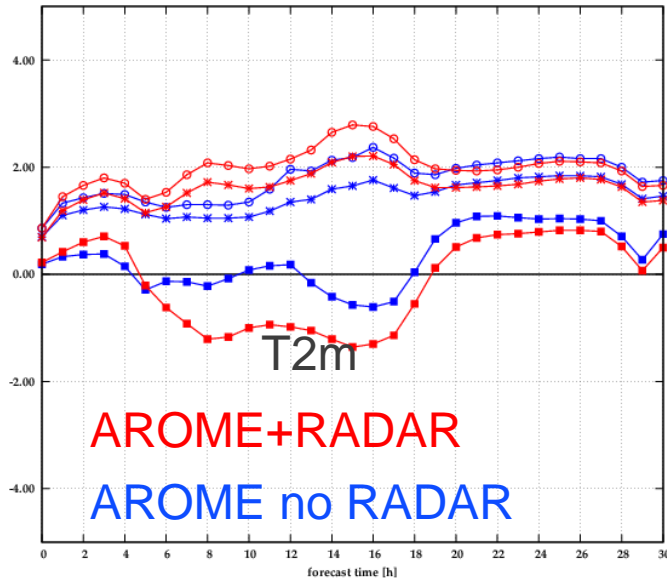
Location Score [L] for domain 04 (NORDOSTOESTERREICH) km resolution
rr (area mean) > 0.05 mm



Station verification:
period: 20110501 - 20110531
run: AR10 00 vs AR11 00
stations: 58
parameter: 2m temperature

2m temperature (58 stations)

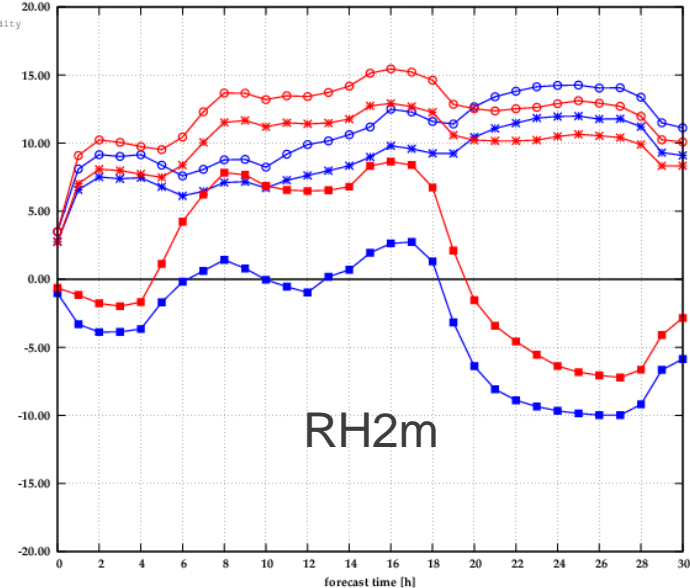
mMAE AR10 00
mBIAS AR10 00
mRMSE AR10 00
mMAE AR11 00
mBIAS AR11 00
mRMSE AR11 00



Station verification:
period: 20110501 - 20110531
run: AR10 00 vs AR11 00
stations: 58
parameter: 2m relative humidity

2m relative humidity (58 stations)

mMAE AR10 00
mBIAS AR10 00
mRMSE AR10 00
mMAE AR11 00
mBIAS AR11 00
mRMSE AR11 00



Next steps

- Get AROME 90L extended domain version operational
- RADAR dealiasing, quality control
- New data and optimization of data usage: RADAR, GPS (refractivity index), IASI, MSG-HR-AMVs
- Introduction of 3D-Var (EDA) in LAM ensemble
- Experiments with 1km AROME and cy38t1 export

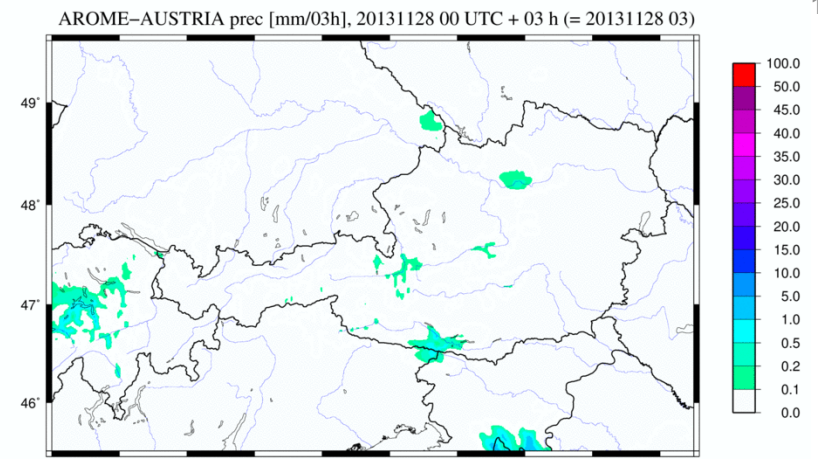
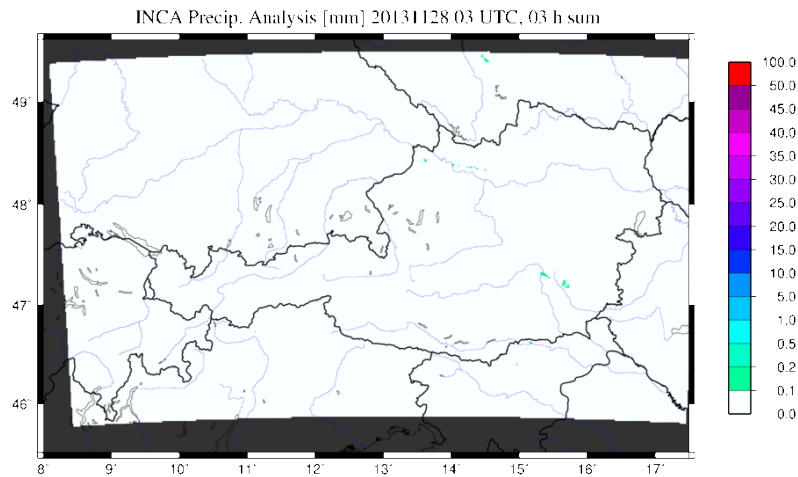
Thanks for your attention

AROME
08.04.2014



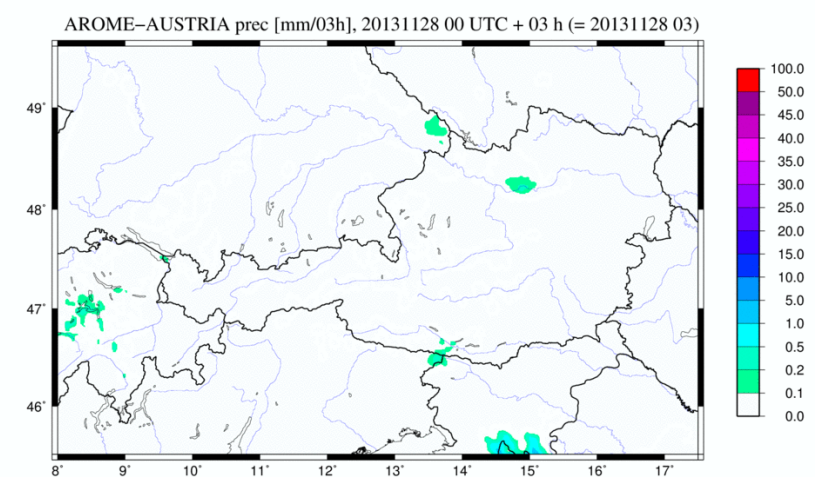
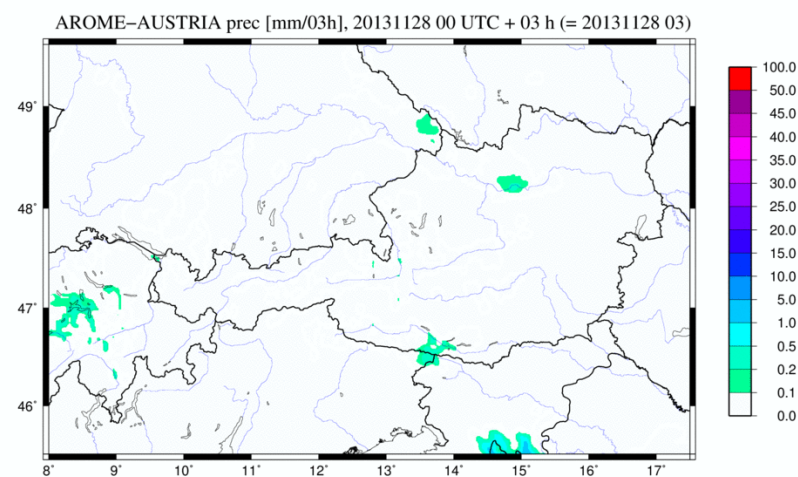
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IDFI: Spurious precipitation at the beginning of model run (28th November 2013 00UTC+3h)



INCA reference

AROME-OPER



AROME+IDFI: NSTDFI=11; TAUS=1,5h

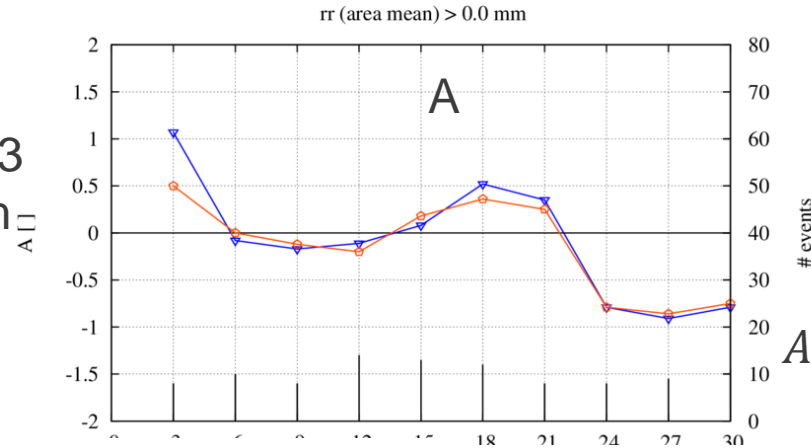
AROME+IDFI: NSTDFI=22; TAUS=1h

IDFI: Spurious precipitation at the beginning of model run

AROME
08.04.2014

SAL- score
10th-30th July 2013
threshold: 0.0mm
NE-Austria

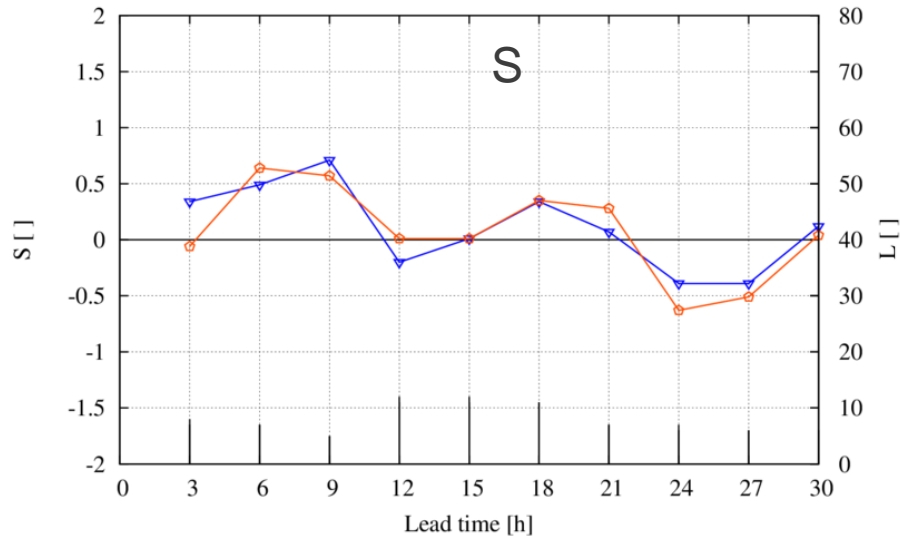
Amplitude Score [A] for domain 04 (NORDOSTOESTERREICH) at 02 km resolution



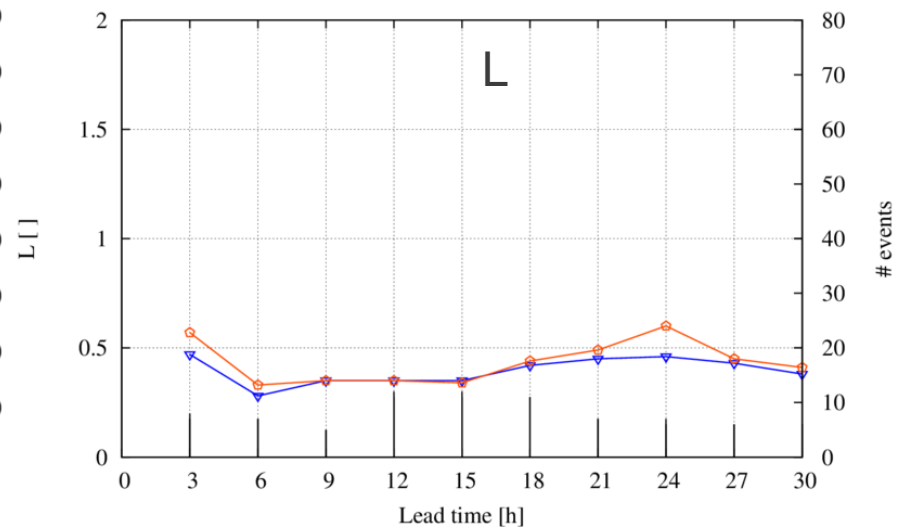
AROME-OPER
AROME-IDFI

$$ANA_{IDFI} = FG + \overline{ANA} - \overline{FG}$$

Structure Score [S] for domain 04 (NORDOSTOESTERREICH) at 02 km resolution
rr (area mean) > 0.0 mm



Location Score [L] for domain 04 (NORDOSTOESTERREICH) km resolution
rr (area mean) > 0.0 mm



AR09 (mean=0.11) —▲— AR05 (mean=0.07) —○—

AR09 (mean=0.39) —▲— AR05 (mean=0.43) —○—

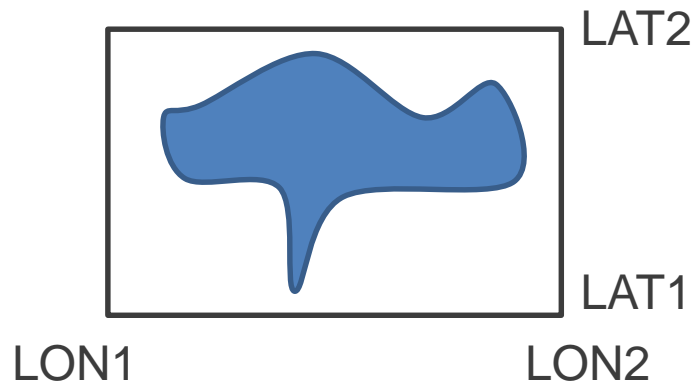


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Tlake assimilation in OIMAIN: 0D-Var

AROME
08.04.2014

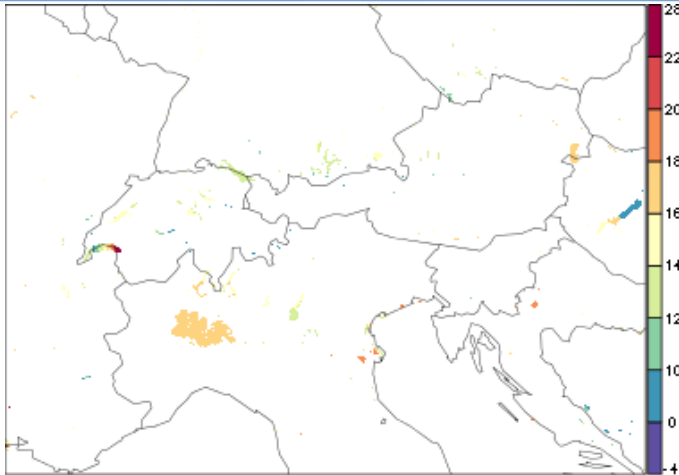
- If available, read ASCII file with box of coordinates, Tlake and estimated Tlake obs error σ_o
- All lake points inside box get new surface temperature Tlake
- $\sigma_b = 2.5K$ everywhere
- New Routine: oi_lakeini.f90 called from oi_main.f90



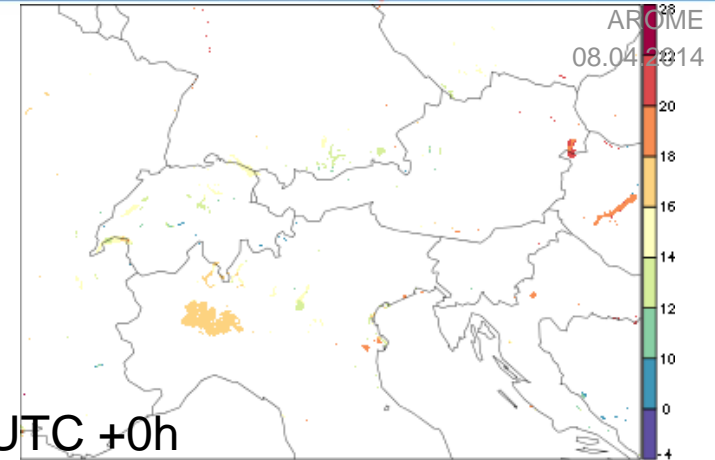
$$T_{lake} = \frac{T_{Lake_b} \sigma_o^2 + T_{Lake_o} \sigma_b^2}{(\sigma_o^2 + \sigma_b^2)}$$

47.4850 47.8110 8.9450 9.7530 24.80 2.00 1 (Lake Constance)

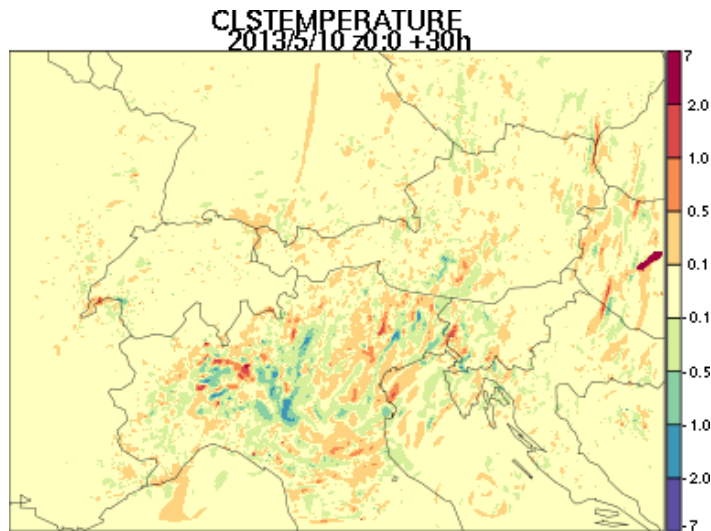
Initialisation of lake temperatures (insitu measurements) 0D-Var in OIMAIN



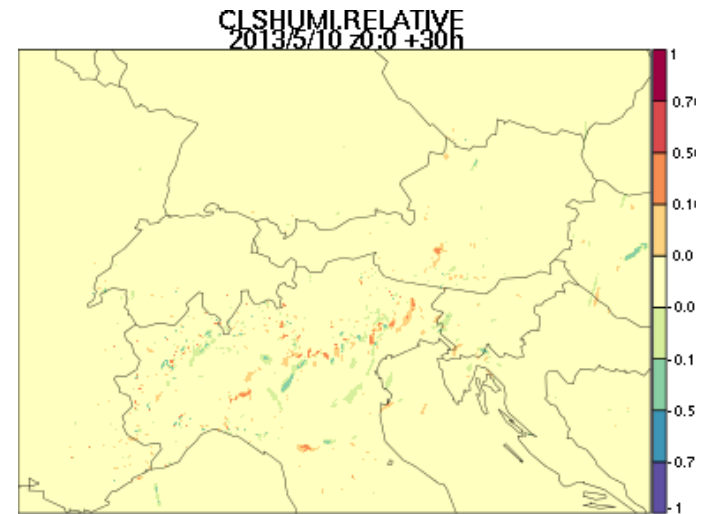
10th May 2013 00 UTC +0h



AROME
08.04.2014



ΔT_{2m} ref-exp +30h

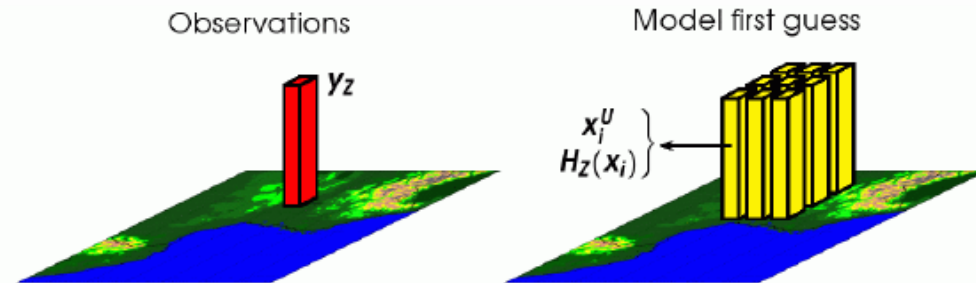


ΔRH_{2m} ref-exp +30h

RADAR-Assimilation (erste Experimente)

AROME

- Formatkonvertierung und Preprocessing durch REMSENS
- Aus den Hydrometeoren qr , qs , qg des first guess wird eine simulierte Reflektivität berechnet.
- Aus den beobachteten und simulierten Reflektivitäten sowie den Feuchteprofilen des „first guess“ werden Pseudobeobachtungen der relativen Feuchte (Vertikalprofile) generiert (1D-Bayes Inversion)
- Qualitätschecks und Ausdünnung 15km²-Boxen
- Die Feuchteprofile werden ähnlich Radiosonden assimiliert



$$y_{po}^u = \sum_{i \in \text{neighbours}} x_i^u \frac{\exp\left(-\frac{1}{2} \|y_z - H_z(x_i)\|^2\right)}{\sum_{j \in \text{neighbours}} \exp\left(-\frac{1}{2} \|y_z - H_z(x_j)\|^2\right)}$$

y_{po}^u : column of pseudo-observed relative humidity,
 y_z : column of observed reflectivities,
 x_i^u : column of relative humidity,
 $H_z(x_i)$: column of simulated reflectivities.

aus Montmerle & Wattrelot 2012

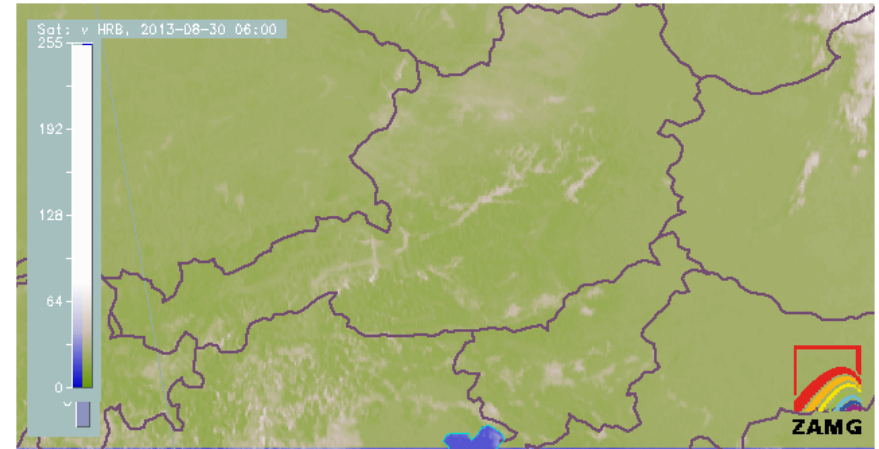
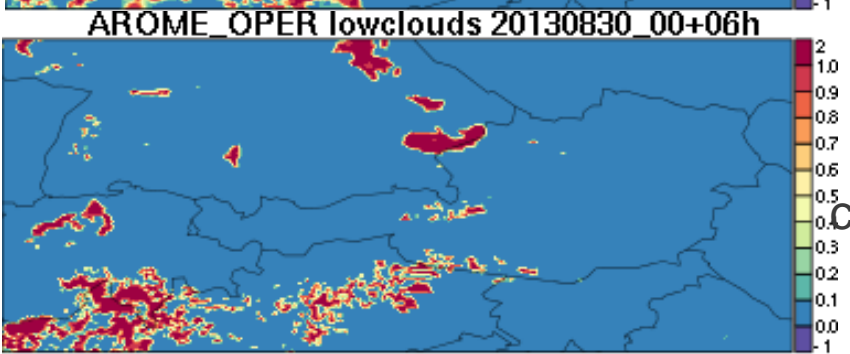
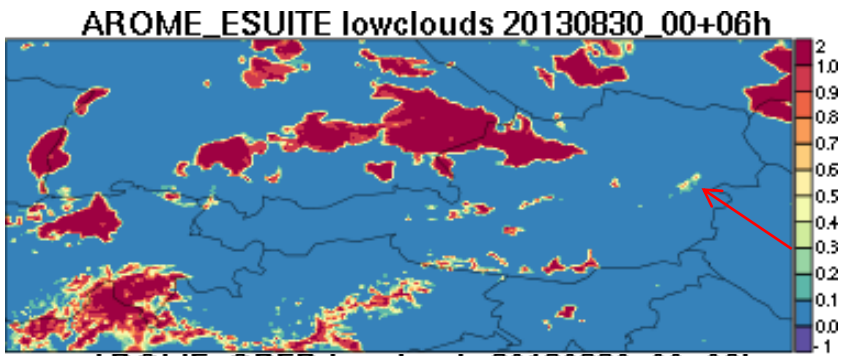
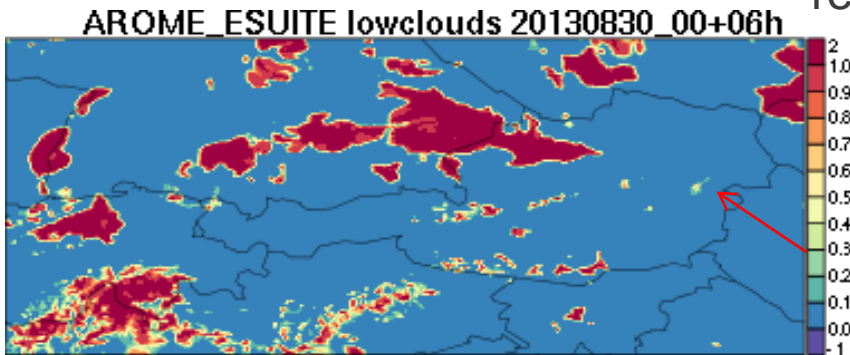
Daten derzeit nur für Testperiode von Austrocontrol verfügbar

Assimilation of pseudo temp observations

AROME
08.04.2014

- Low clouds (stratus) are often not captured in AROME in Alpine valleys
- Wrong T and Q profiles -> idea: create pseudo radio sounding (obsoul) from several SYNOP (valley floor to mountain tops) and assimilate them
- Innsbruck, Zell am See, Schladming, Mürztal
- Comparison with sounding at Innsbruck looks fine
- Case study: Impact small, differences in physics cy36t1->cy37t1op1 have more impact

low clouds reference



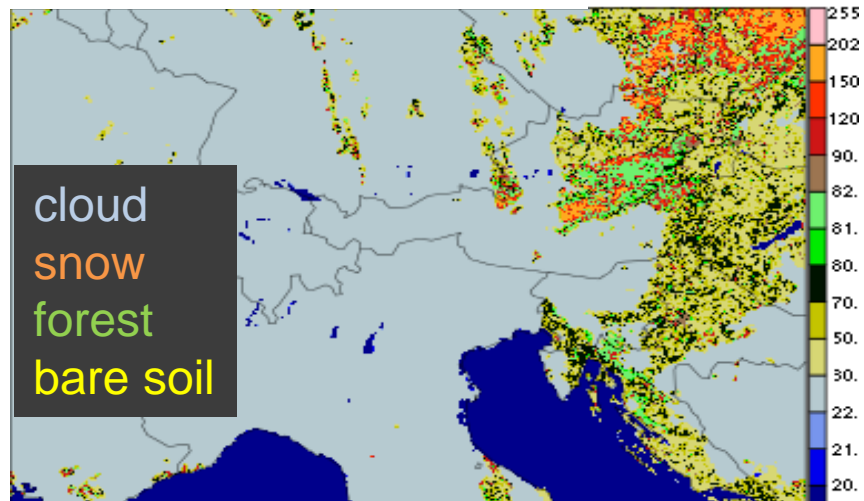
low clouds
With pseudo temps

low clouds
cy36t1 instead cy37t1op1

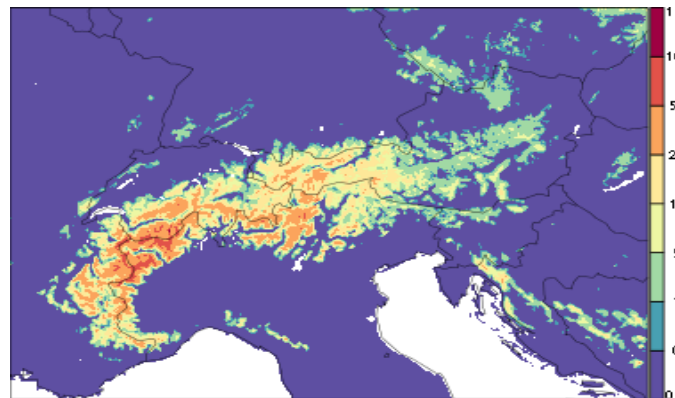
Snow initialisation (project: SNOWGRID)

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08.04.2014

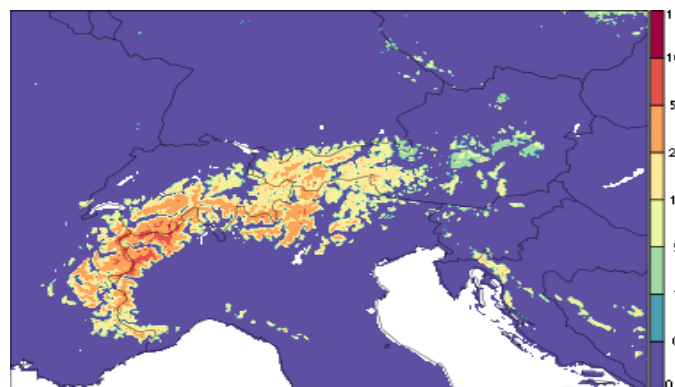
ENVEO-Cryoland
MODIS-snow cover 1km



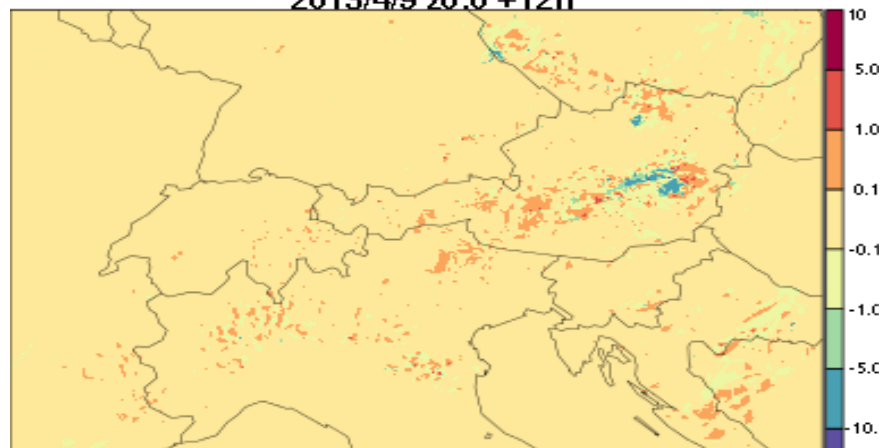
CLSTEMPERATURE
2013/4/9 20:0 +12h



SWC kg/m²
reference



With modified snowcover (OIMAIN)
9th April 2013 00 UTC



ΔT2m exp-ref 9th April 2013 00 UTC+12h

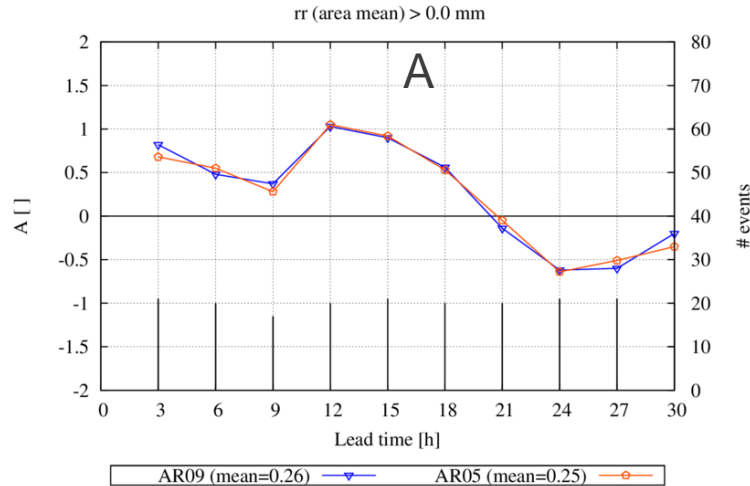
IDFI: Spurious precipitation at the beginning of model run



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08.04.2014

SAL- score
10th-30th July 2013
threshold: 0.0mm
Austria

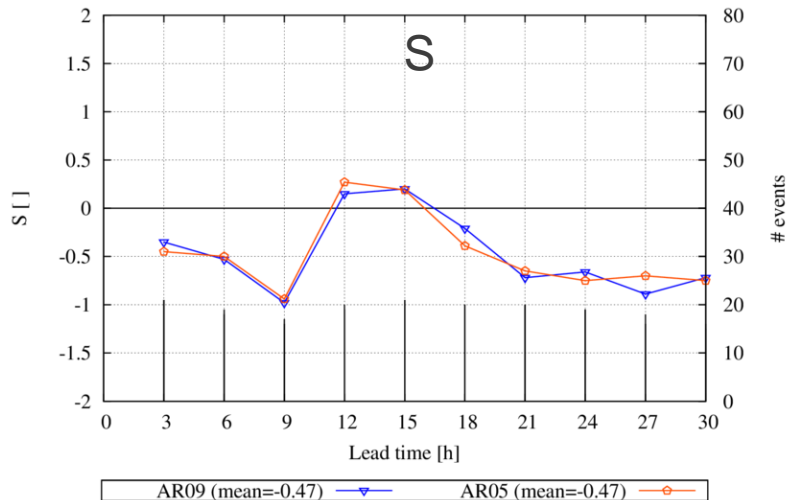
Amplitude Score [A] for domain 06 (OESTERREICH_GESAMT) at 02 km resolution



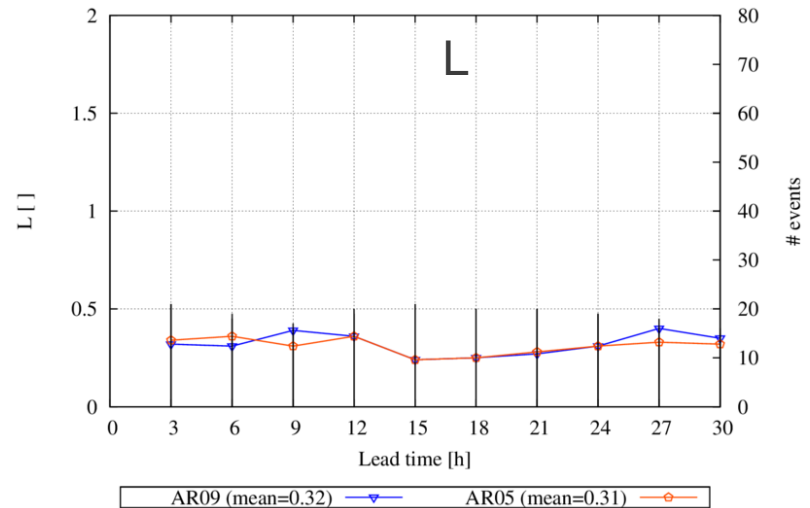
AROME-OPER
AROME-IDFI

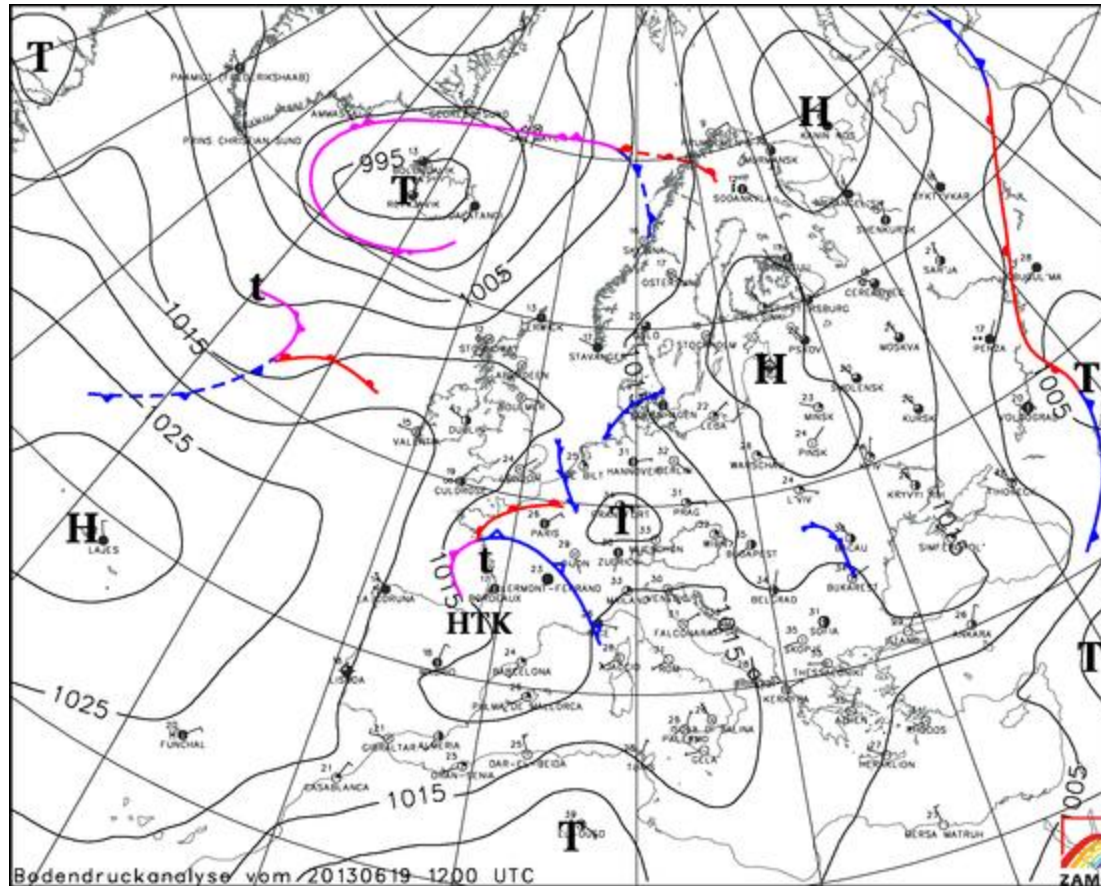
$$ANA_{IDFI} = FG + \overline{ANA} - \overline{FG}$$

Structure Score [S] for domain 06 (OESTERREICH_GESAMT) at 02 km resolution
rr (area mean) > 0.0 mm



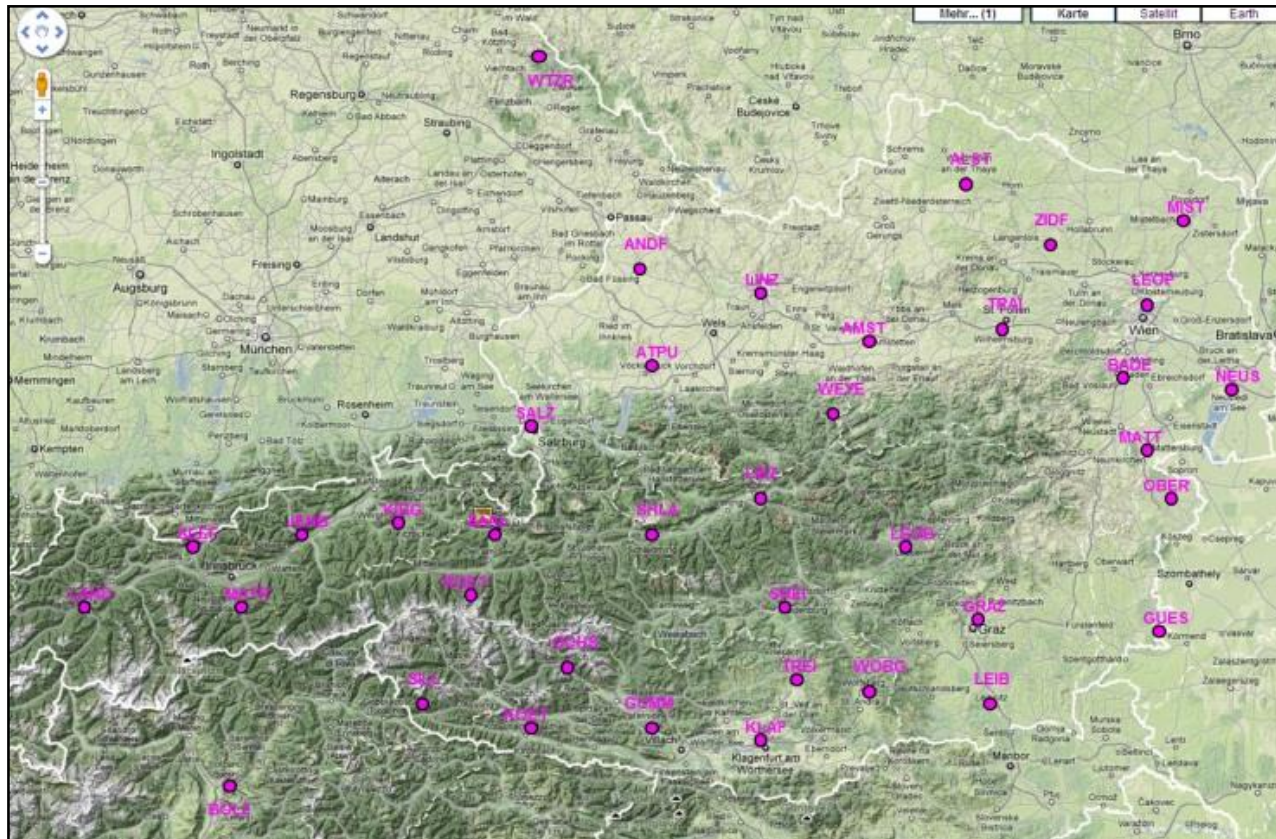
Location Score [L] for domain 06 (OESTERREICH_GESAMT) km resolution
rr (area mean) > 0.0 mm





GPS-Stationsnetz in Österreich

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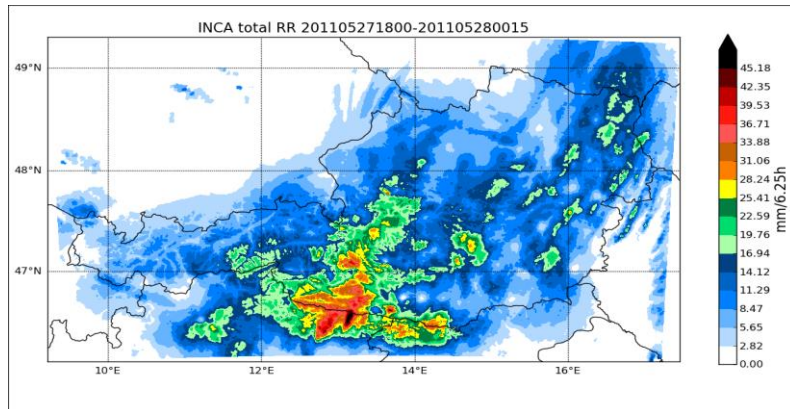


- Daten von ca. 40 GPS Referenzstationen (TU Wien prozessiert Daten von Wien-Energie)
- statische Biaskorrektur

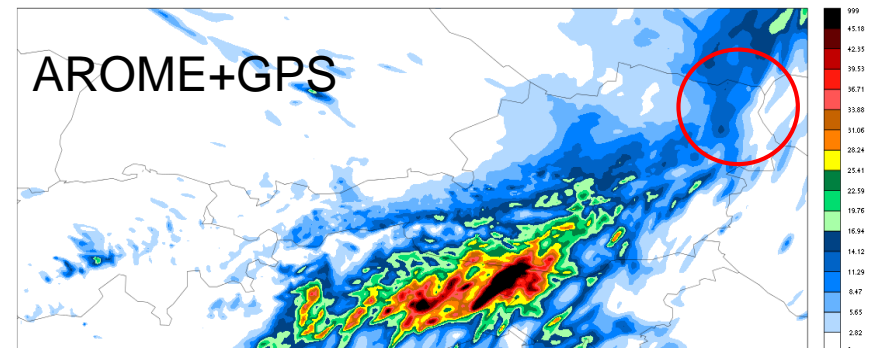
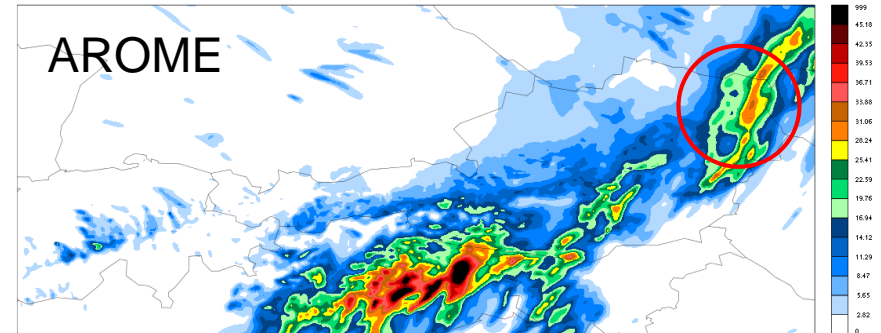
Assimilation österreichischer GPS-ZTD Daten

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08.04.2014

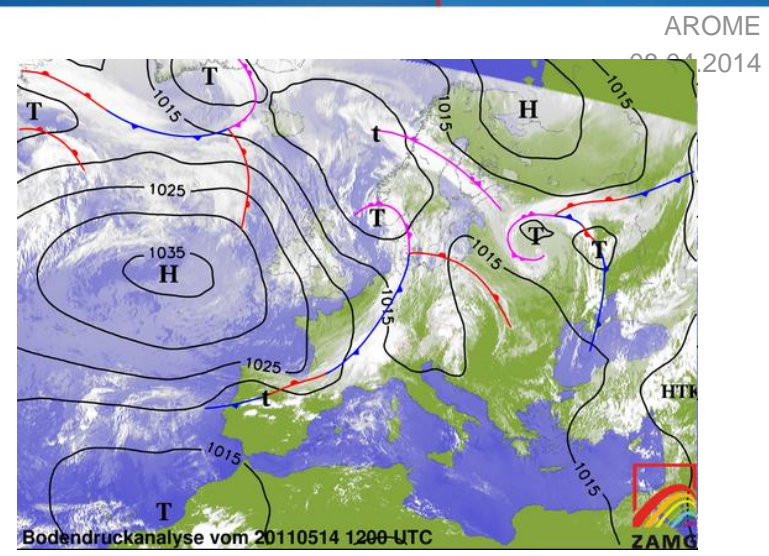
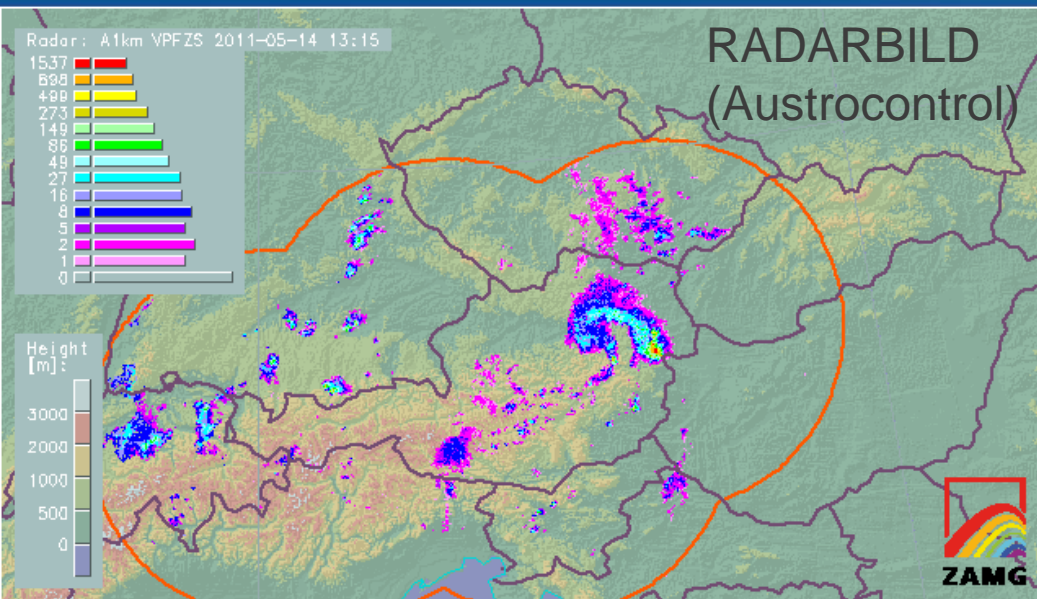
INCA



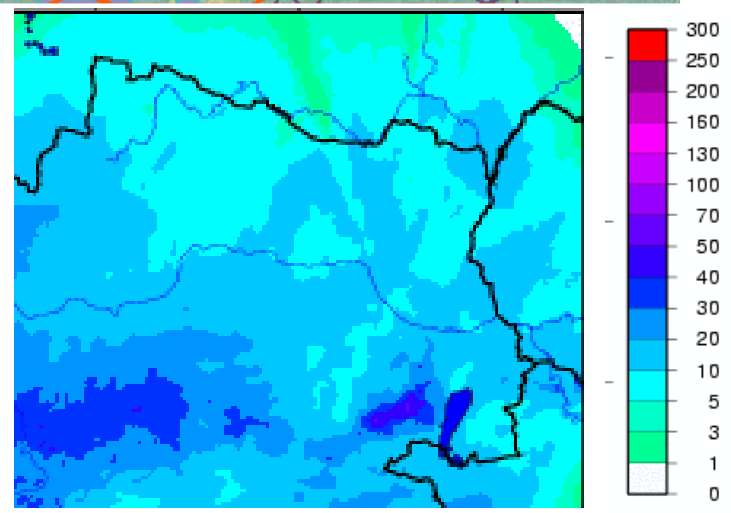
2011052718-24UTC 6h accum



Hagelgewitter im Burgenland 14.5.2011



INCA-Analyse
12UTC+24h

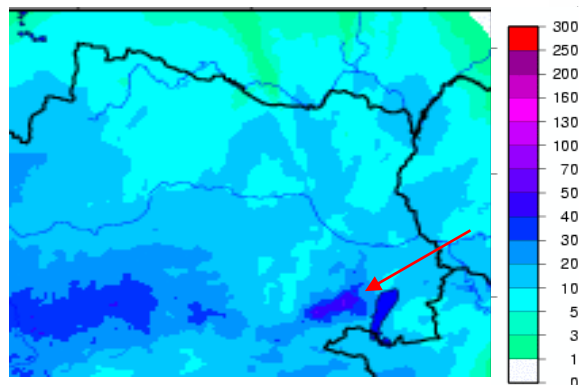


Hagelgewitter 14.5.2011 12UTC+24h Niederschlag

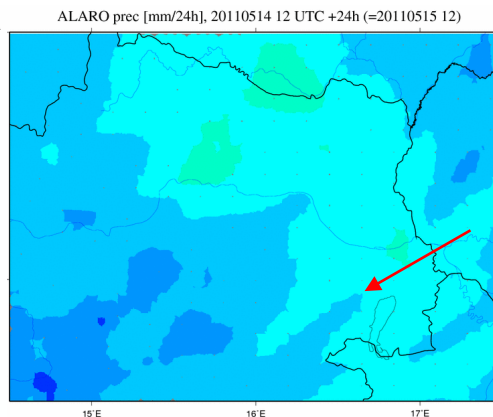


AROME
08.04.2014

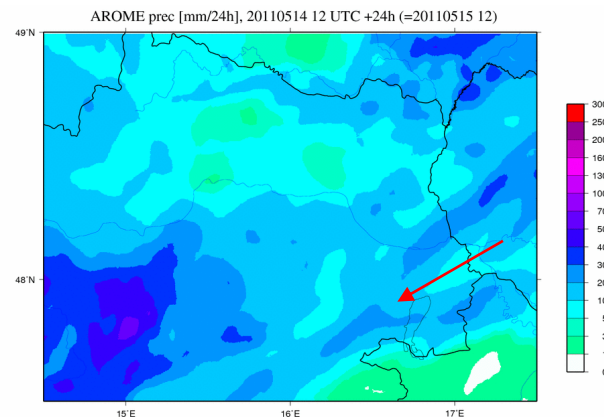
INCA



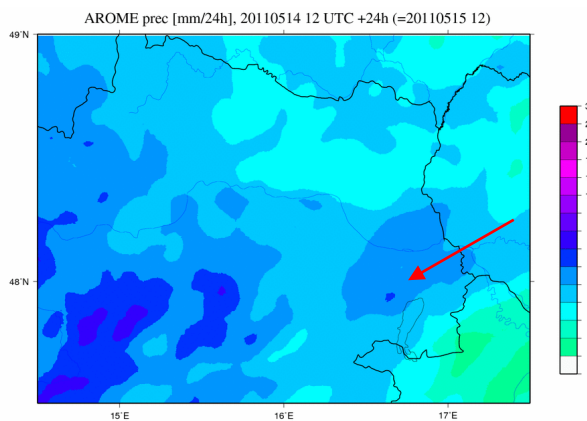
ALARO



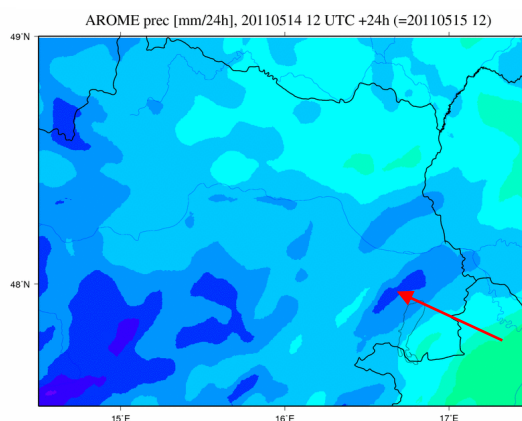
AROME



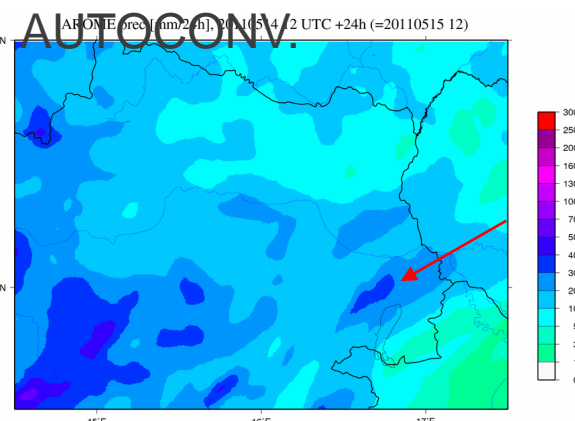
AROME+ASSIM



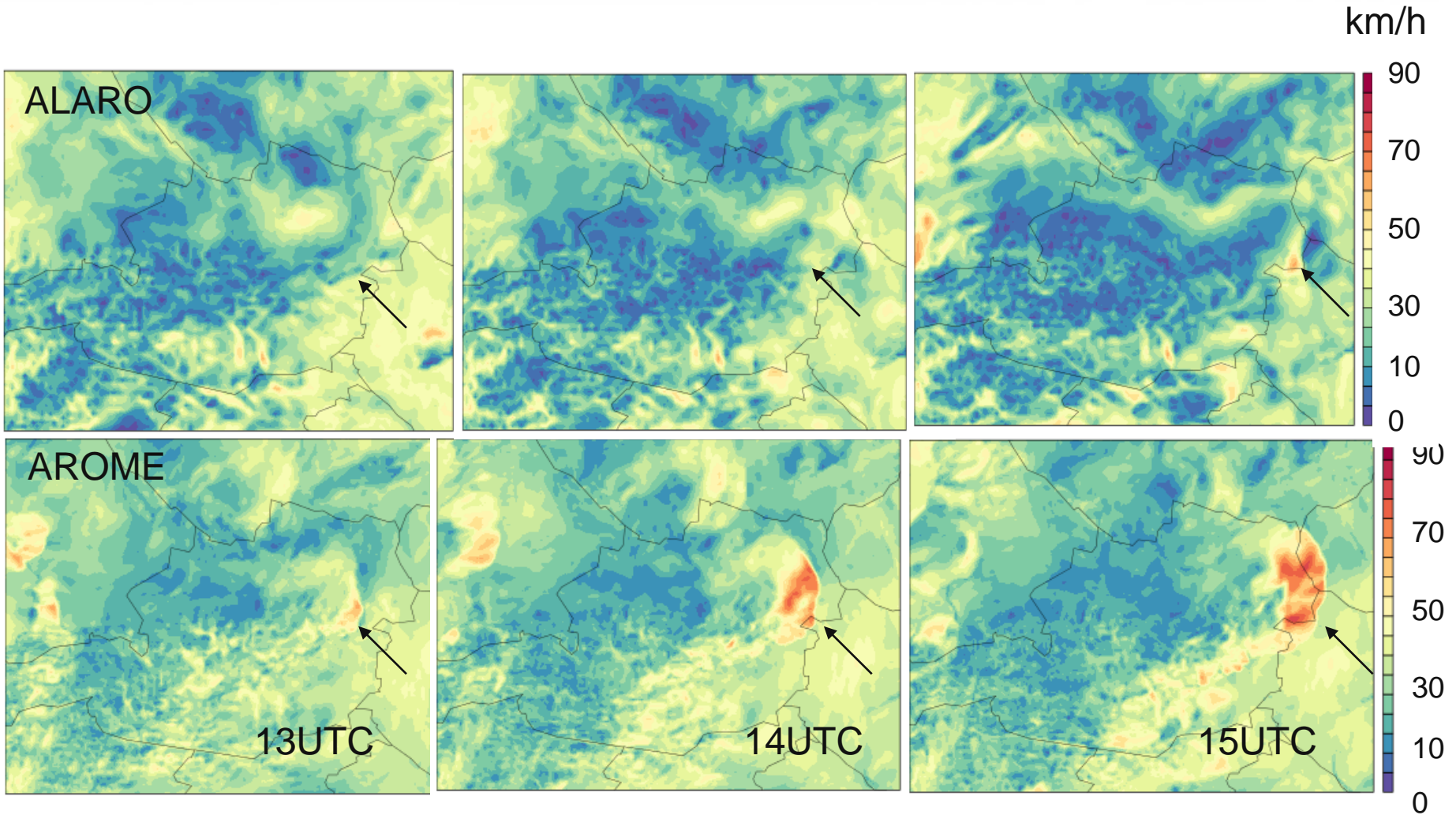
AROME+ASSIM+PILOT



AROME+ASSIM+PILOT+



1h-Böen am 14.5.2011



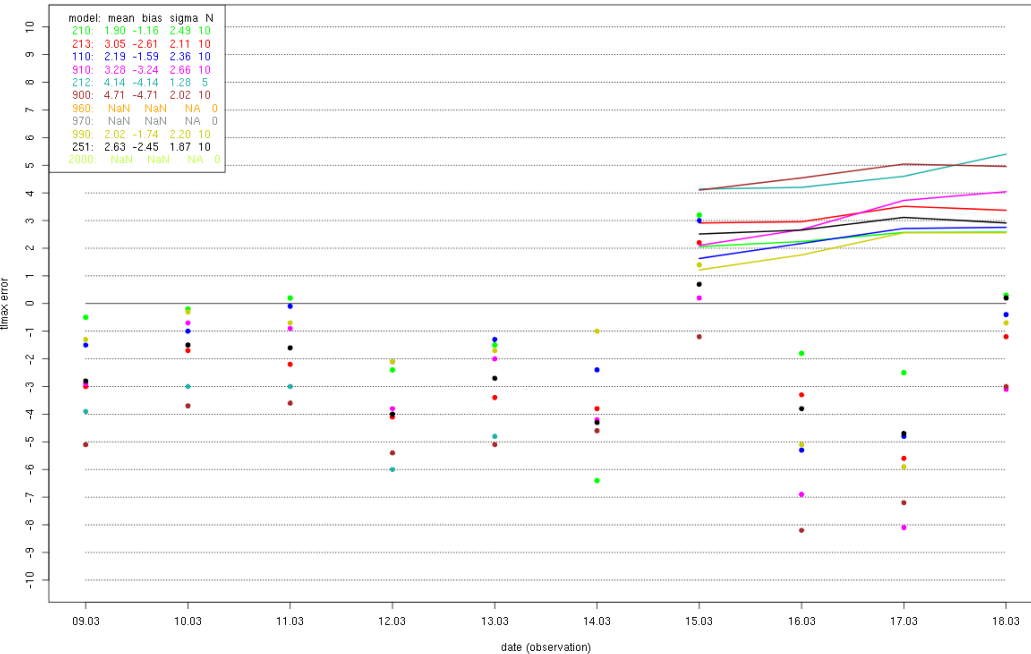
Eisenstadt: 111,6km/h, Neusiedl 79,2 km/h, Hohe Warte 57,6 km/h



AROME
08.04.2014

Cold Tmax bias in AROME during sunny spring period

tmax day-0 | station: 11331 | modprog: multi | init: 00 | period: 20140309 - 20140318

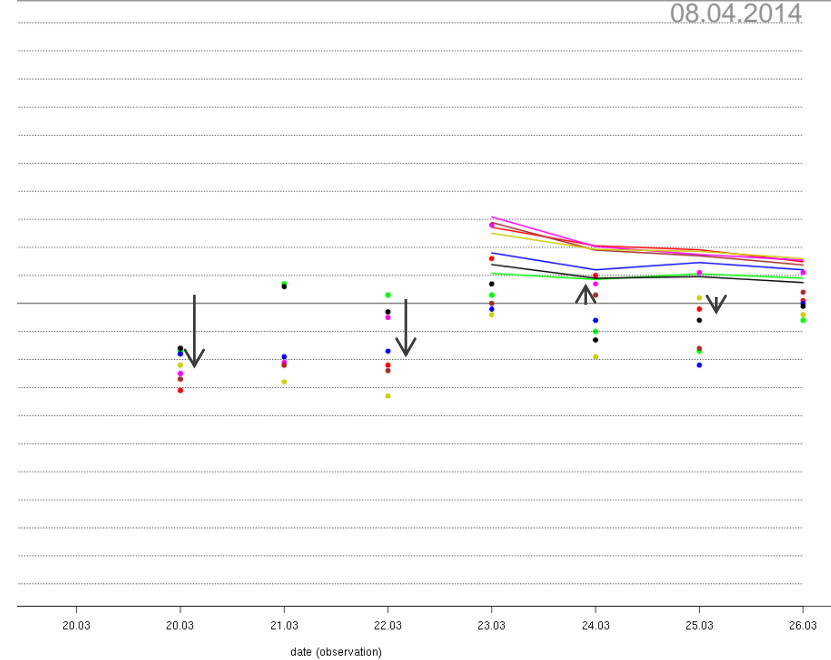


AROME
ALARO
IFS GME
COSMO

tmax day-0 | station: 11331 | modprog: multi | init: 00 | period: 20140317 - 20140326

AROME

08.04.2014



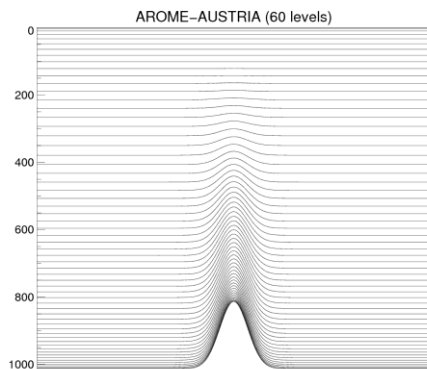
Intervention:
RWPIA in OIMAIN: 0.025->0.75

Tmin OK

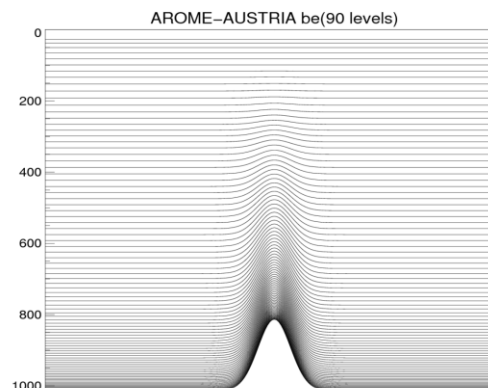
AROME at ZAMG: pre-operational and test versions

AROME
08.04.2014

Pre-operational:
432x320 GP L60 2,5km



Test version: 600x432GP
L90 2,5km



Levels like
MF-be

AROME-AUSTRIA Domain & Topography

