Meteorological analysis and forecast data as input for drought monitoring

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Content

- INCA Analysis system
- Forecast models entering ADA
- Predictability of drought in summer 2015

ZAMG input parameters for ADA

INCA Analyses

Parameter	ab Jahr	Forecast (d)	Auflösung	Anmerkung
Minimumtemperatur (24 h) [°C d^{-1}]	2003	3 bzw. 10	1 km*)	
Maximumtemperatur (24 h) [°C d^{-1}]	2003	3 bzw. 10	1 km	
Mitteltemperatur (24 h) [°C d^{-1}]	2003	3 bzw. 10	1 km	
Tagesmitteltemperatur (12 h) [°C d^{-1}]	2003	3 bzw. 10	1 km	abhängig von Modellen
Globalstrahlung [MJ m^{-2} d^{-1}]	2003	3 bzw. 10	1 km	Umrechnung auf MJ m^{-2}
Relative Luftfeuchte [% d^{-1}]	2003	3 bzw. 10	1 km	oder Evapotranspiration
Wind [m s^{-1} d^{-1}]	2003	3 bzw. 10	1 km	oder Evapotranspiration
Evapotranspiration (PM) [mm d^{-1}]	2003	3 bzw. 10	1 km	
Schneebedeckung (SWE) [mm d^{-1}]	2003	3 bzw. 10	1 km	vorerst nur Ja/Nein (mit W. Schöner besprechen)
Niederschlag [mm d^{-1}]	2003	3 bzw. 10	1 km	

*) Die räumliche Auflösung der Wettermodelle liegt ursprünglich bei 4.8km für die nächsten 3 Tage (ALARO) und ca. 16.km für die nächsten 10 Tage (ECMWF). Die Daten werden jedoch auf das 1km INCA Gitter interpoliert und in dieser Auflösung zur Verfügung gestellt.

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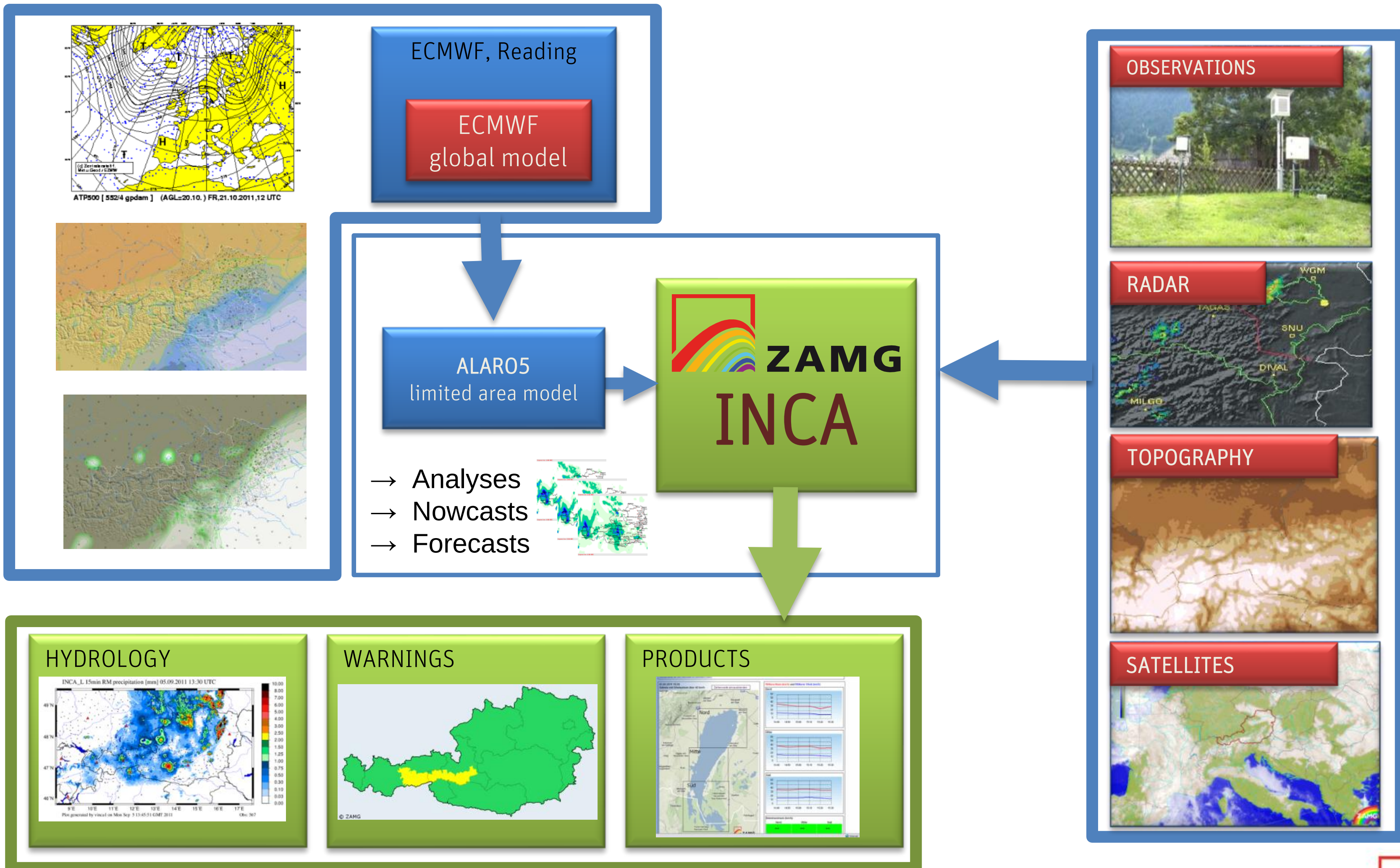
INCA – Integrated Nowcasting through Comprehensive Analysis



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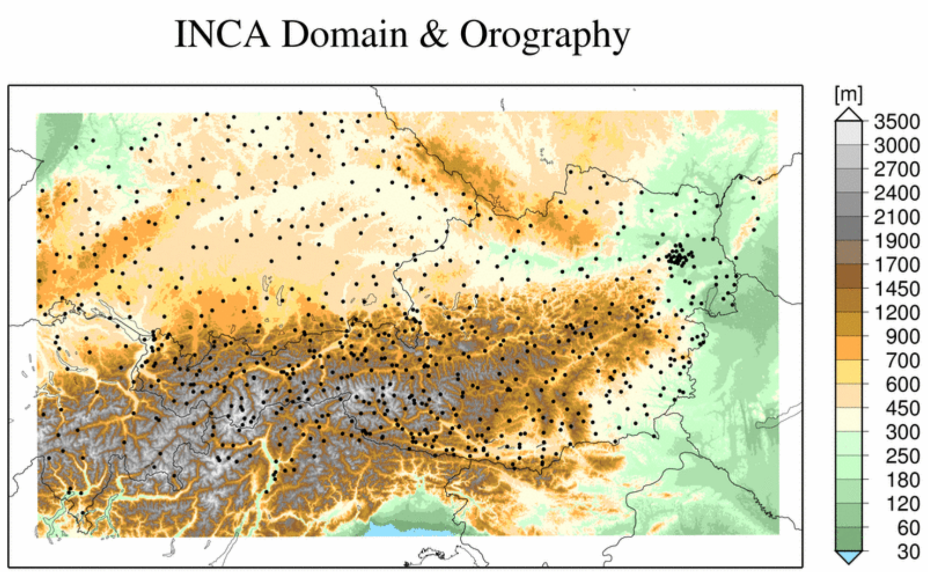
INCA details

Austrian domain:
Region: Eastern Alps
Domain size: 700x 400 km
Elevation range: 100 - 4000 m
Resolution:
horizontal: 1km,
vertical: 125 - 200 m,
time: 5 min - 1 h



2-D Analyses und Forecasts
- Precipitation
- Precipitation type
- Cloudiness
- Global radiation

3-D Analyses und Forecasts
- Temperature
- Humidity
- Wind

2-D Convective Analyses Fields
- CAPE, CIN, LCL, LFC
- Instability Indices (LI, Showalter, ..)
- Trigger-Temperature-Deficit
- Equivalent Potential Temperature
- Moisture convergence
- Mass convergence

Other derived 2-D Fields
- Snowfall line
- Icing potential
- Wind chill

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INCA nowcasting strategy

	Precipitation	Cloudiness	Temperature & Humidity	Wind
Analysis background	Radar data	Satellite data	NWP forecast (ALARO)	NWP forecast (ALARO)
Nowcasting method	Extrapolation with motion vectors	Extrapolation with motion vectors	Persistence + modelled trend	Presistence + modelled trend
NWP forecast	ALARO+ ECMWF	ALARO	ALARO	ALARO
Nowcasting limit	6 hours	6 hours	3 to 12 hours (depending on stability)	6 hours

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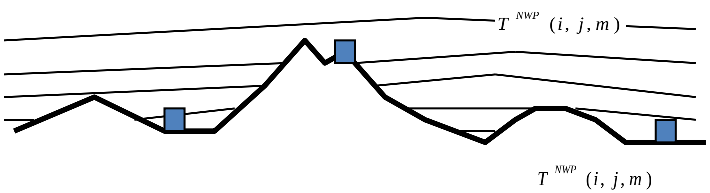
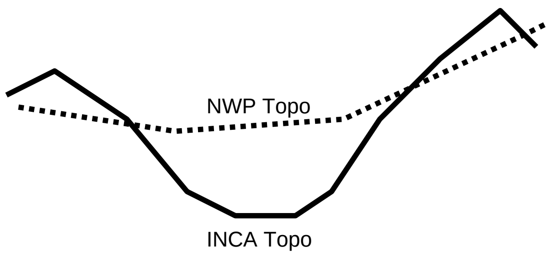
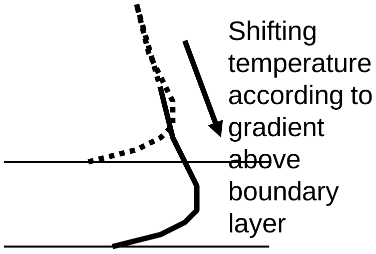
Temperature Analysis I

Step 1: 1st guess from ALADIN Output (trilinear Interpolation)

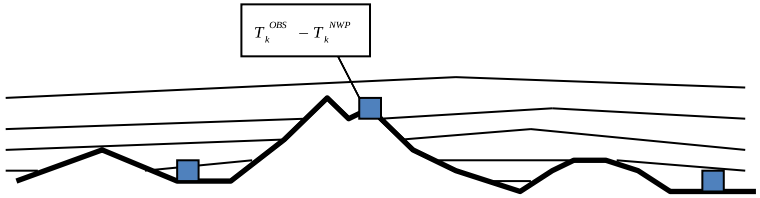


Extrapolation into valleys

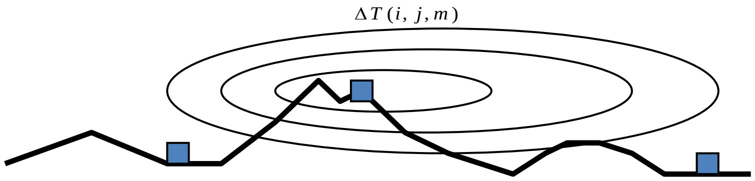




Step 2: Calculating the differences 1st guess and OBS (3D, then 2D)

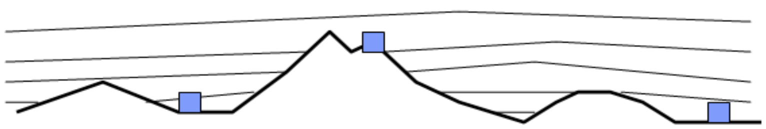


Step 3: Interpolation of differences (3D, then 2D)



Step 4: Superposition

$$T^{INCA}(i,j,m) = T^{NWP}(i,j,m) + \Delta T(i,j,m)$$



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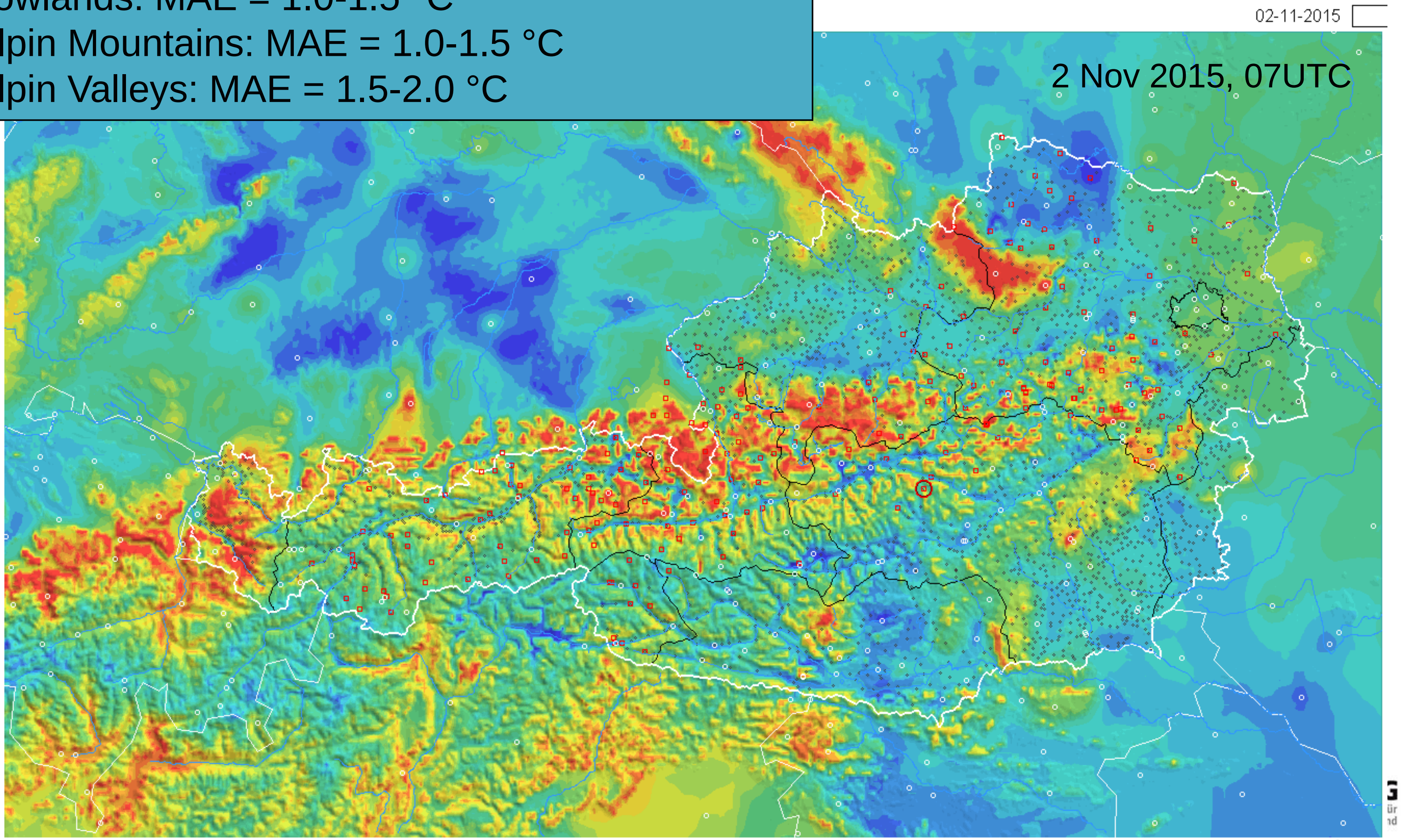
Temperature Analysis II

09/11/2015

Quality of Analysis
Lowlands: MAE = 1.0-1.5 °C
Alpin Mountains: MAE = 1.0-1.5 °C
Alpin Valleys: MAE = 1.5-2.0 °C

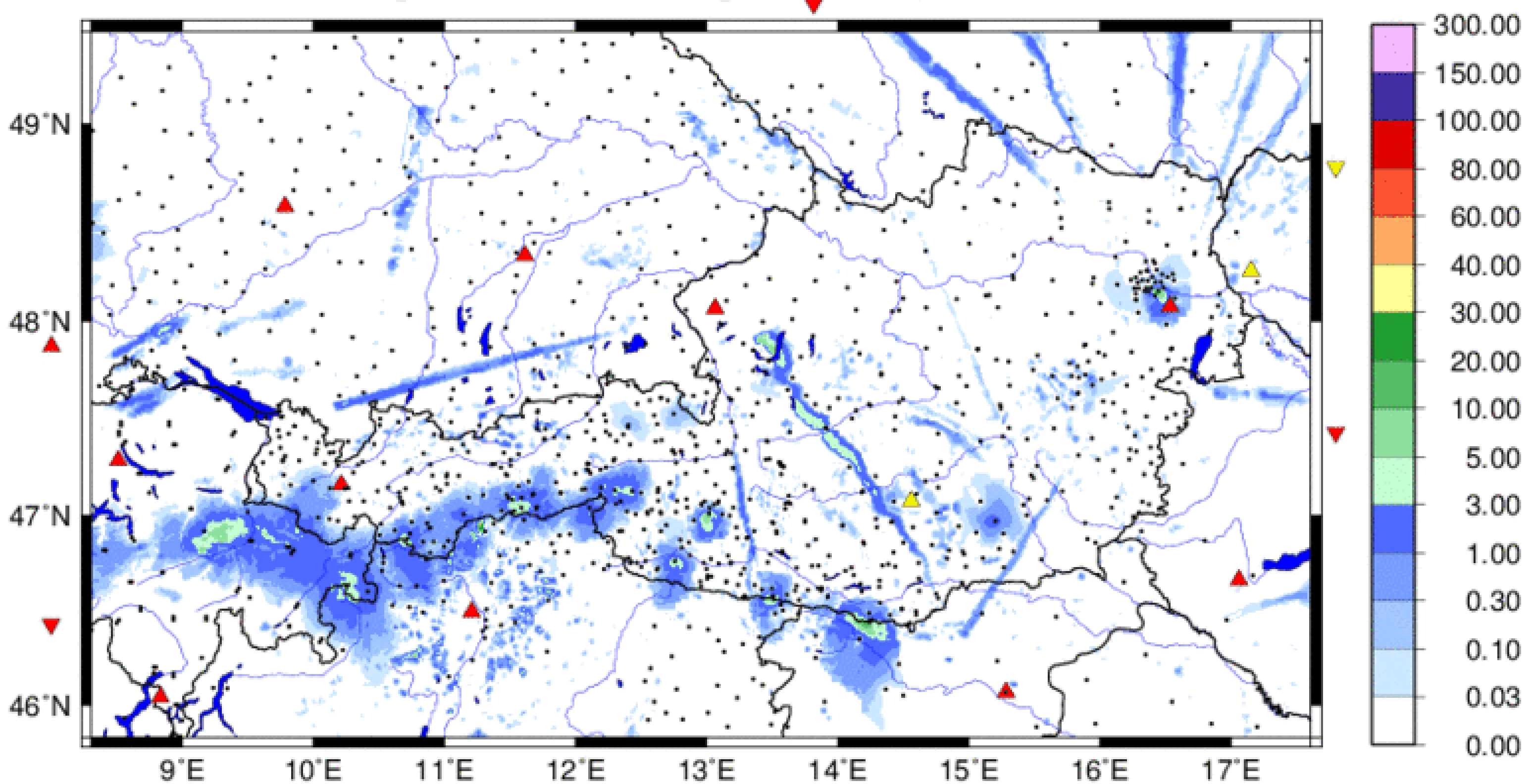


Improvements of the precipitation analysis fields by applying quality control

1. **Station data consistency check**
   e.g. compare 10min precipitation to aggregated 1min obs / sunshine data
2. **Plausibility filter**
   Detect unrealistically high/low values, NaNs, etc.
3. **Climatological limits**
   defined according to time of the year and accumulation period
4. **Flatfilter**
   Identify and remove suspicious series of constant values
5. **Singlefilter**
   Identify and remove single "outliers" (i.e., values that appear suspiciously high / low compared to neighbourhood or radar data)
6. **Accumulation filter**
   same as 5) but for longer accumulation periods
7. **SP filter**
   Cross check with cloudiness
8. **Radar filters**
   Remove artefacts in the radar fields
9. **Blacklist**
   Permanently exclude bad stations from analysis

INCA precipitation without advanced quality control

INCA 24h RM_noqc Accumulated Precipitation [mm] 17.08.2013 06:00 UTC (–24h)



Plot generated by vmapp on Fri Aug 23 08:44:05 GMT 2013 Obs: 1072

Daily precipitation analysis without Quality Control

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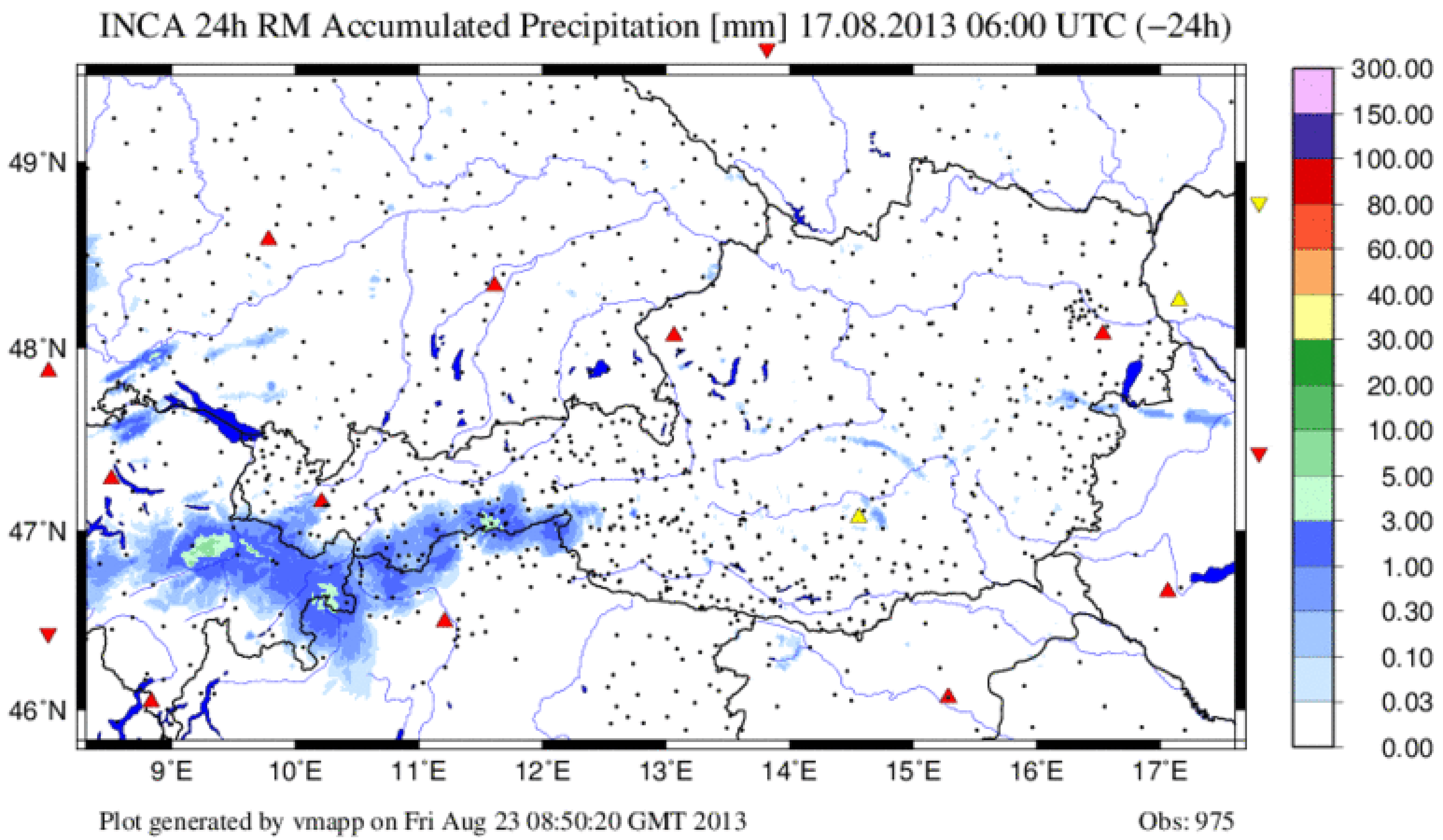
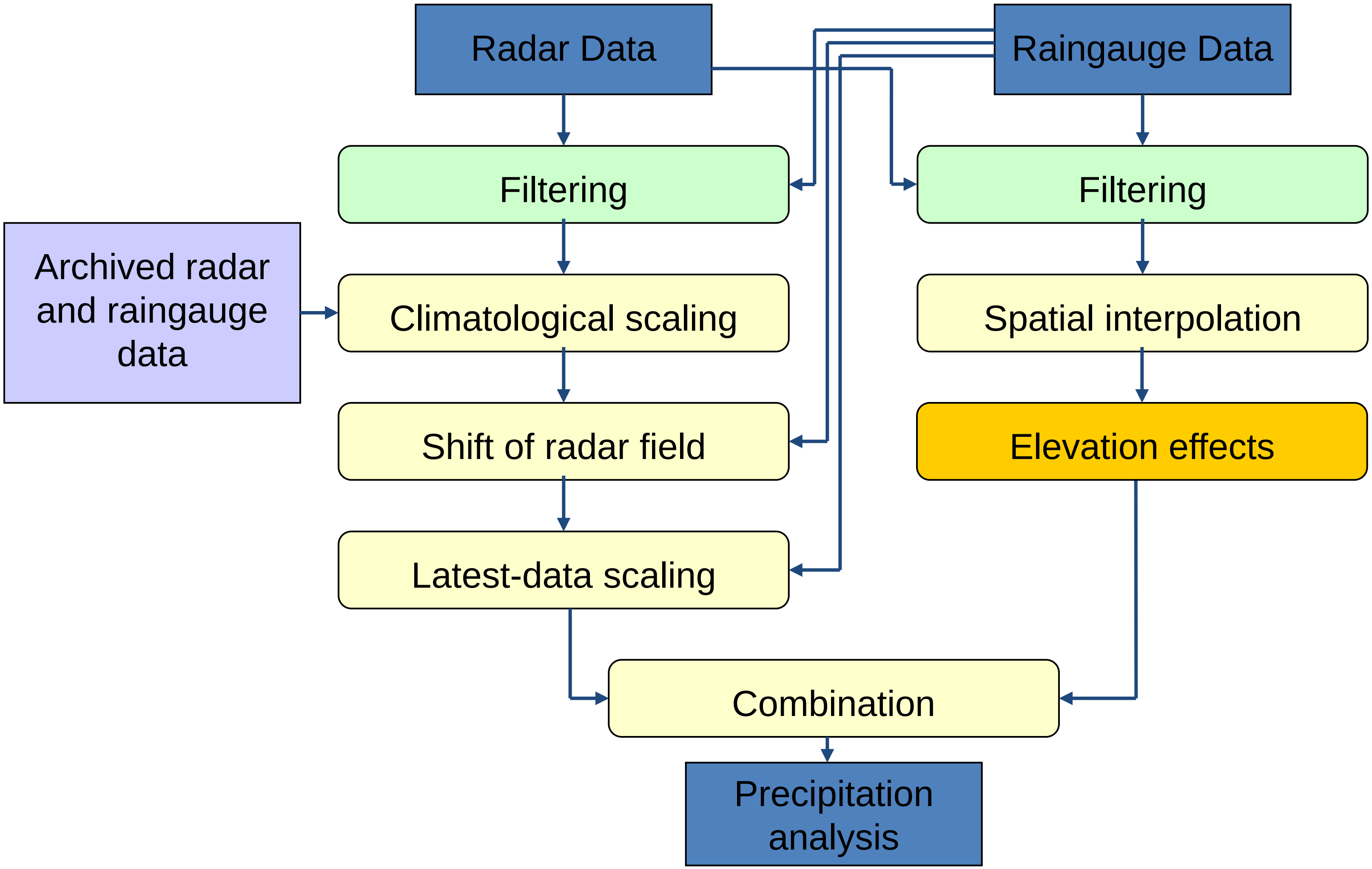
INCA precipitation with advanced quality control

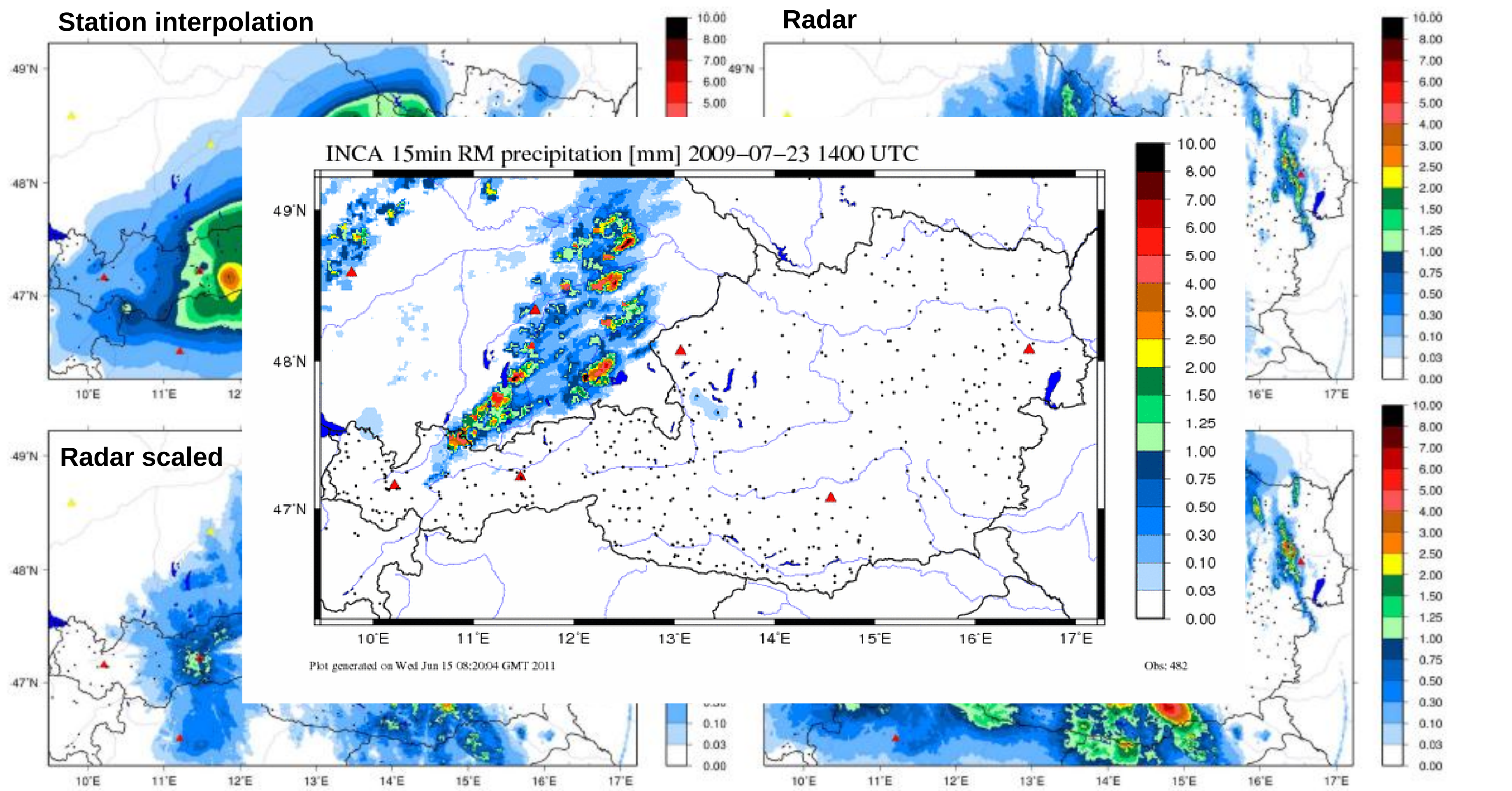


Daily precipitation analysis with Quality Control

Precipitation analysis



Components of INCA precipitation analysis



18 July 2009, 07:30 UTC

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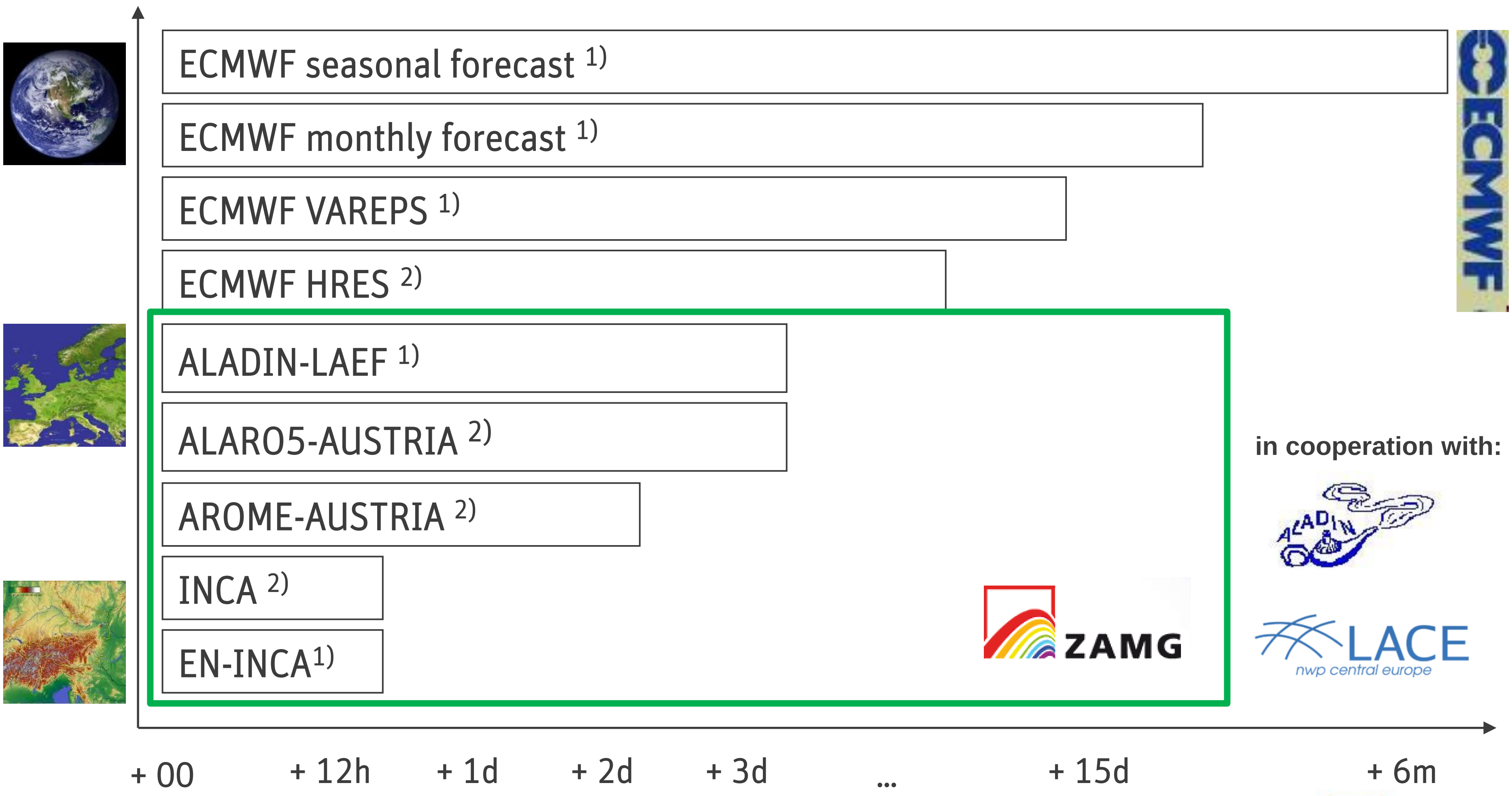
NWP models used at ZAMG



[1] probabilistic system

[2] deterministic system

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Fact-Sheet NWP models

ECMWF Monthly/Seasonal Forecast System

ECMWF
16km, 00/12 UTC, +240h lead time, 6h time steps; ~8h after T0

ECMWF-EPS
32km, 00/12 UTC, +360h lead time, 50 members, 6h time steps; ~9h after T0

ALARO
5km, 00/06/12/18 UTC, +72h lead time, 1h time steps, ~3h after T0

LAEF
11km, 00/12 UTC, +72h lead time, 16 members, 1h time steps, ~4h after T0

AROME (operational since 01/2014, major upgrade in 08/2014)
2.5km, 8 runs, +60h lead time, 1h time step, ~3h after T0

INCA
1km, 5min/15min/hourly, +12h lead time, 5min/15min/1h time step, ~10 to 45min after T0

Ensemble INCA (operational by end 2013)
1km, 15min/hourly, +12h lead time, 15min/1h time steps, ~30 to 45min after T0

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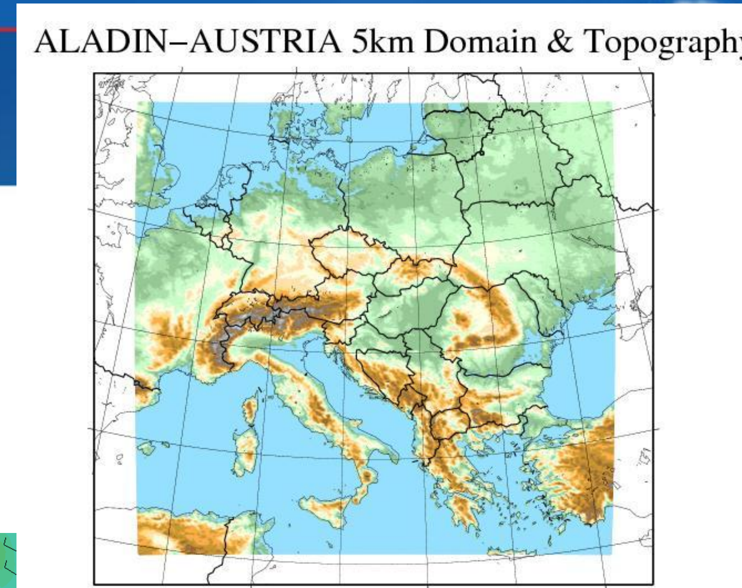
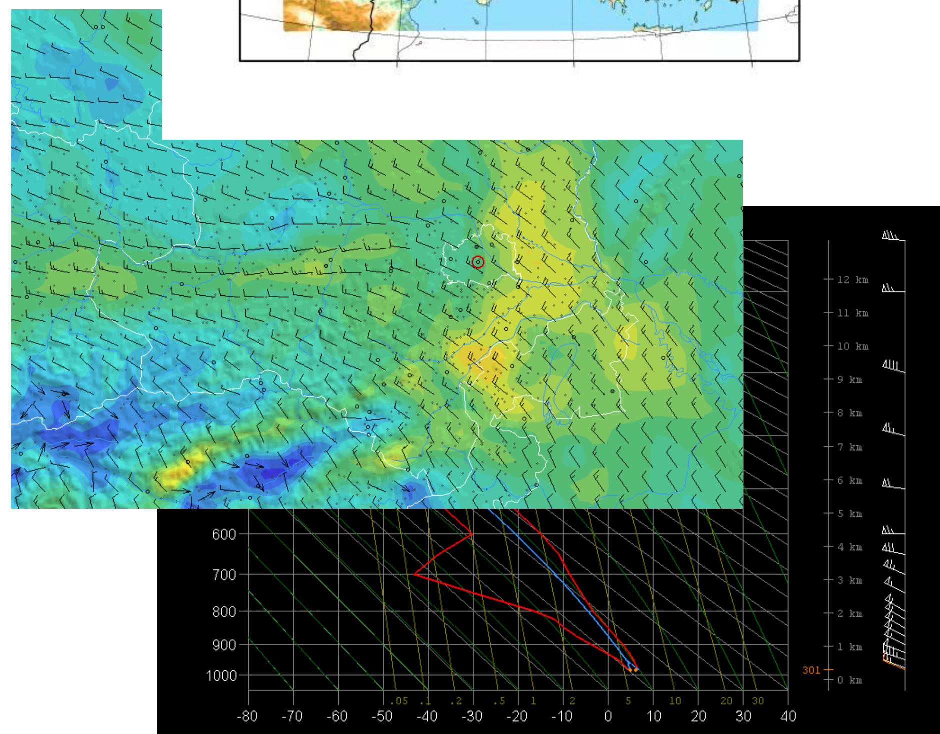
Operational 5km model ALARO

Horizontal resolution	4.8 km (600x540)
Vertical resolution	60 Levels
Runs / day	4 (00,06,12,18 UTC)
Forecast Range	72h
Output-Frequency	1/h
Model time step	180sec
Coupling model	IFS (ECMWF)
Coupling update	3h
Assimilation	Opt. Interpolation





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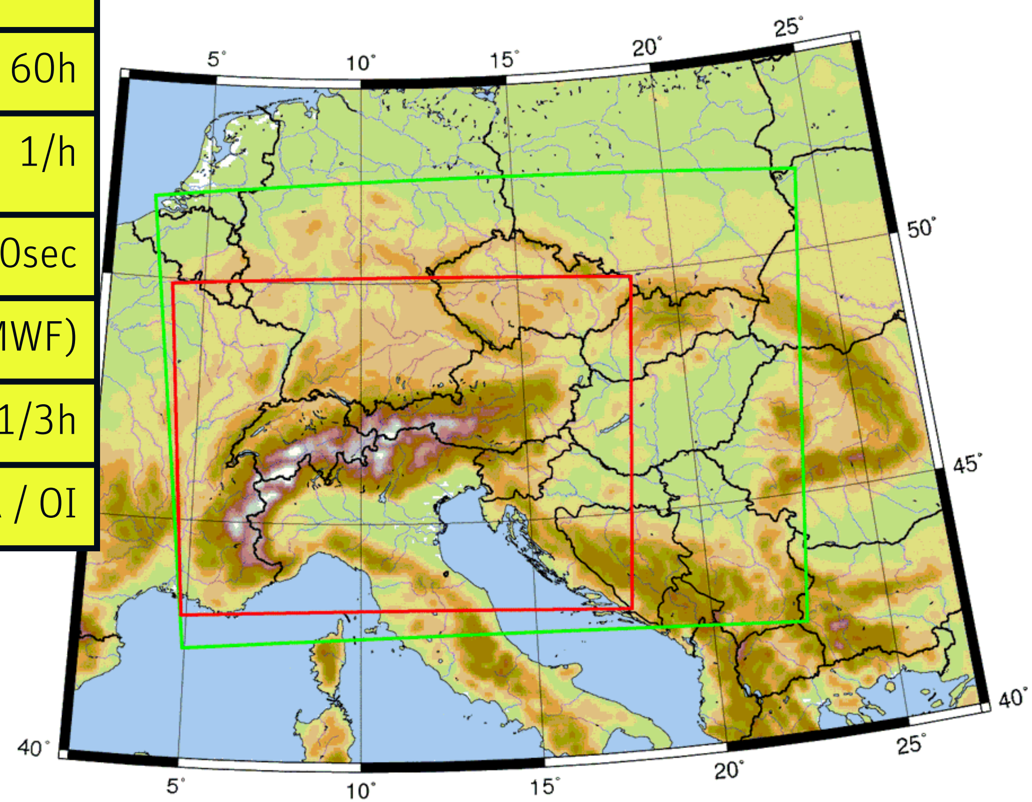
Operational 2.5 km model AROME

Horizontal resolution	2.5km (600x432)
Vertical resolution	90 Levels
Runs / day	8 (00,03,..18,21 UTC)
Forecast Range	60h
Output-Frequency	1/h
Model time step	60sec
Coupling model	IFS (ECMWF)
Coupling update	1/3h
Assimilation	3DVAR / OI

major upgrade 2014/08



Assimilated observation data in AROME

Observation type	assimilated fields	data source
SYNOP+TAWES	T2m,RH2m,U10m,V10m, ϕ	ZAMG+OPLACE
AMDAR (airplanes)	U,V,T	ZAMG+OPLACE
GEOWIND (SAT-Winde) MSG3	U,V	OPLACE
TEMP (radiosondes)	U,V,T,Q,ϕ	ZAMG+OPLACE
PILOT	U,V	ZAMG
WINDPROFILER*)	U,V	ECMWF MARSARCHIV/OPLACE
MSG3-SEVIRI	WV-radiances	OPLACE
NOAA16/18/19+MetOp-A-B AMSU-A,-B,MHS,HIRS	radiances	OPLACE
MetOp-A-B IASI	radiances	OPLACE
ASCAT wind	U10m,V10m (25km)	ZAMG/EUMETSAT
GPS*)	zenith total delay (ZTD)	TU-Vienna
RADAR*)	reflectivity / radial winds	Austrocontrol/Remote Sensing
SNOWGRID snow cover	SWE	ZAMG

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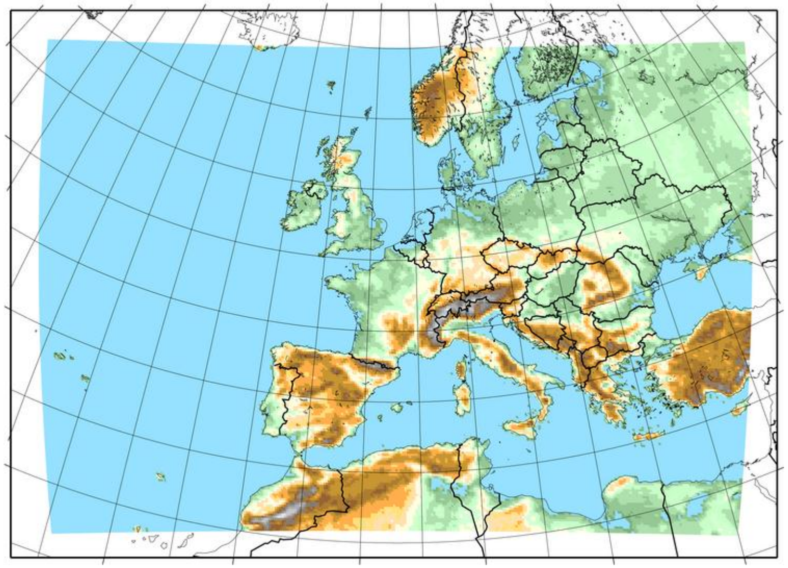
Operational LAMEPS ALADIN-LAEF

Ensemble size	16+1+1
Horizontal resolution	11 km
Vertical resolution	45 level
Runs/Day	2 (00, 12 UTC)
Forecast range	72h
Output-Frequency	1h
Model time step	360s
Coupling-Model (time-lagged)	*ECMWF-EPS (global SV Vectors)*
Coupling-Update	6h

ALADIN–LAEF Domain & Topography



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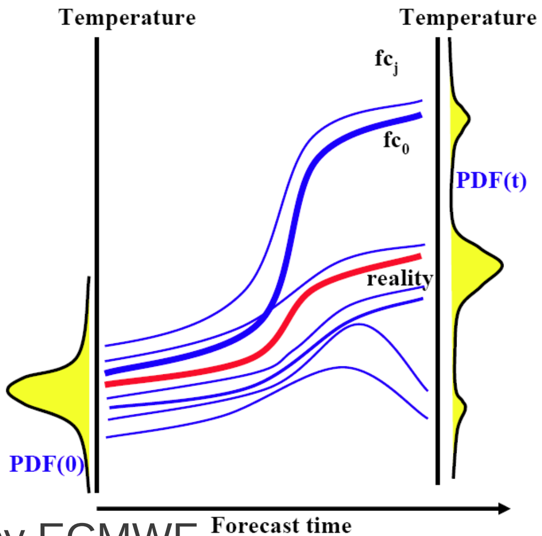
Forecast errors

Uncertainty in numerical weather forecast originate from different sources:

- errors in initial conditions (atmosphere, soil/surface conditions, sea/lake temperature) trough incomplete data coverage
- errors in initial conditions entering due to observation errors (quality control)
- for LAM models: errors entering at the domain boarder
- "errors"/limitation in description of physical processes (microphysics, turbulence, etc)
- errors due to limited numerical accuracy in solving equations
- ... other sources

➡ quantifiying these uncertainties leads us to "ensemble prediction systems" (EPS)

➡ EPS used for short range and long range (up to seasonal prediction and climate scenarios)



by ECMWF

Stochastic physics – trying to quantify model error

Stochastic “noise” entering model tendency equations to simulate uncertainty in models physics:

$$\frac{\partial e_j}{\partial t} = A\left(e_j, t\right) + P'\left(e_j, t\right)$$

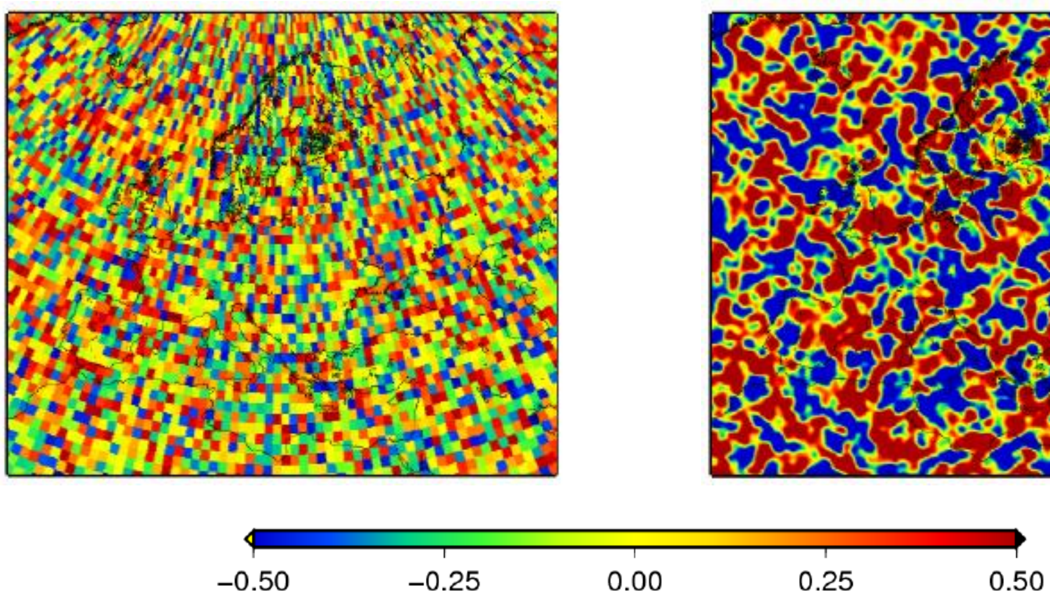
Modified tendency equation (by adding perturbation P’)

$$P'_j\left(e_j, t\right) = \left(1 + r_j(\lambda, \varphi, t)_{D,T}\right) P_j\left(e_j, t\right)$$

- surface temperature
- liquid soil water content
- frozen soil water content
- snow albedo
- snow reservoir water content
- snow density
- water intercepted by vegetation

old pattern generator

new pattern generator



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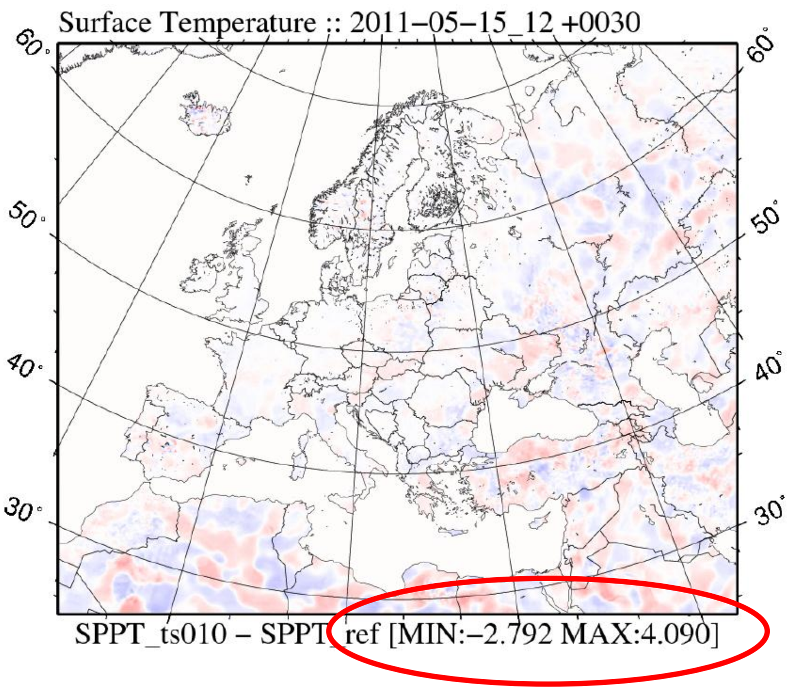
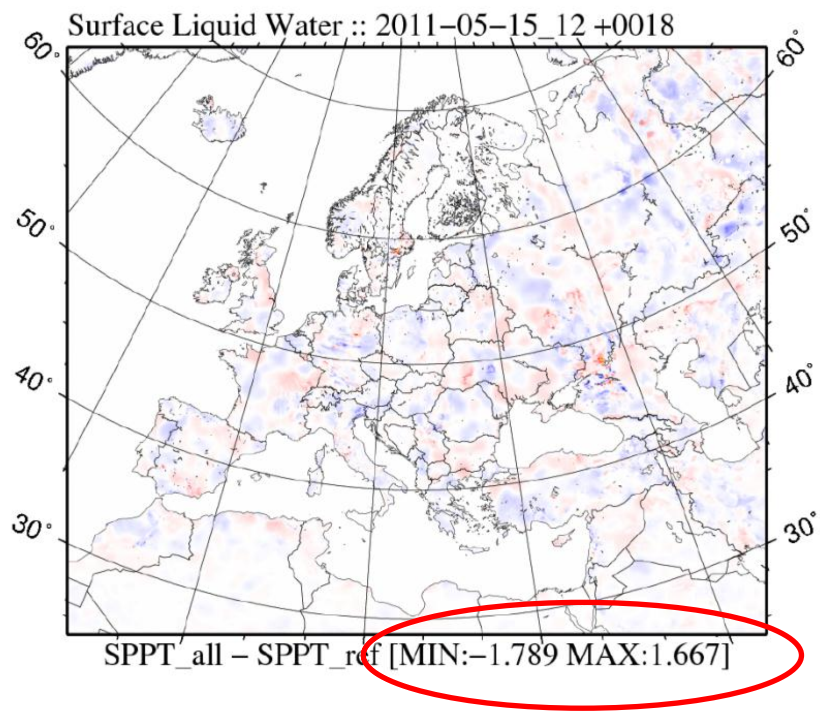
Stochastic physics – sensitivity studies II

Significant effect on drought relevant forecast parameters (example: soil temperature and soil humidity)





stochastic physics is part of EPS

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Seasonal forecasts

- Seasonal forecasts provide information about the „climate“ to be expected in the coming months

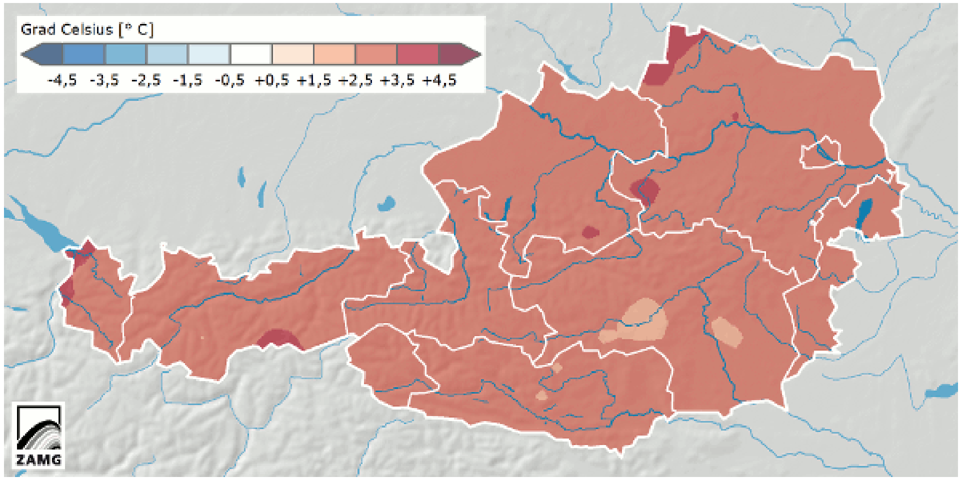
→ Different to weather forecasting systems, seasonal forecasts should not be considered to predict the atmospheric conditions at a certain time but as prediction of an averaged (over time) state of the atmosphere.

- Seasonal forecasts are possible thanks to the fact that the averaged state of the atmosphere is related to a number of components which themselves show variations on long time scales (seasons and years) and, to a certain extent, are predictable (e.g. ENSO).

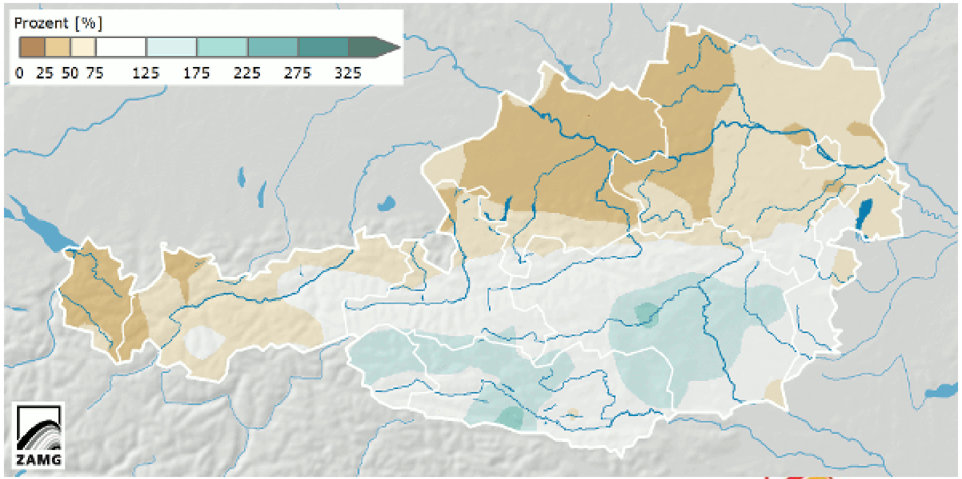
- For Seasonal forecasts a probabilistic approach is needed since it is only possible to predict the range of likely “climate” scenarios for the coming months.

Summer 2015 - July

Temperature anomaly



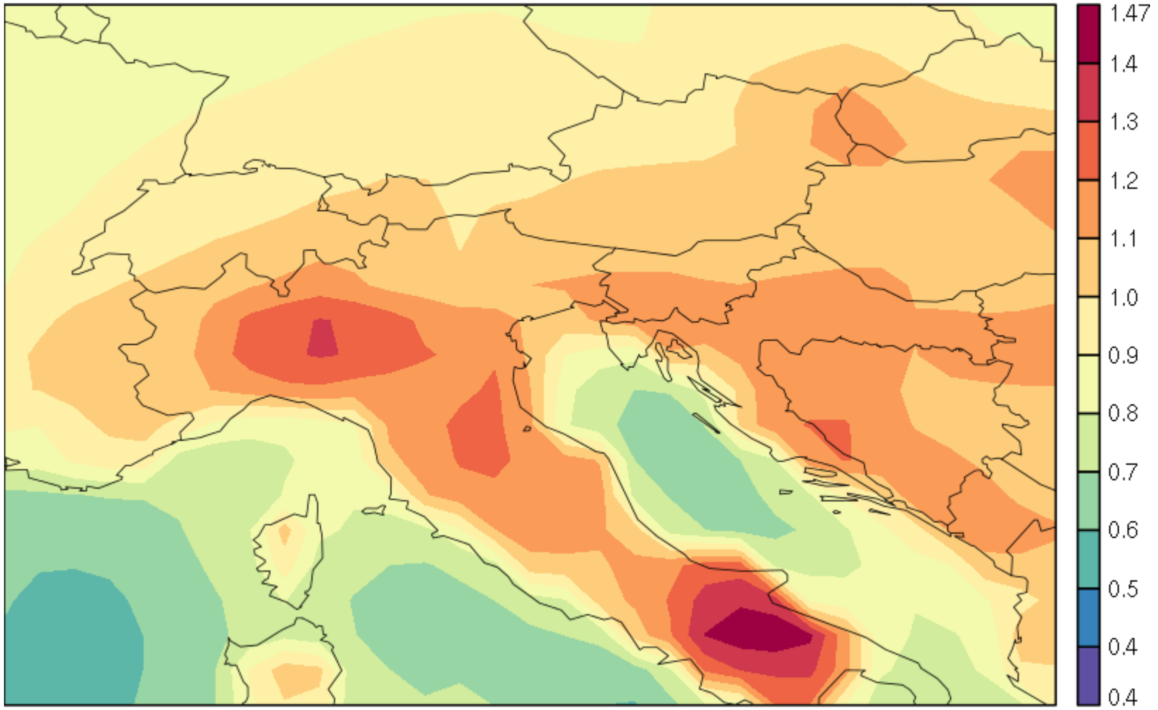
Precipitation anomaly



- Warmest July in the history, more than 3 K above the climate average
- dry in the north and east

Predictability of July temperatures – Fcst from Jan 2015

Temperature anomaly of **ensemble mean**



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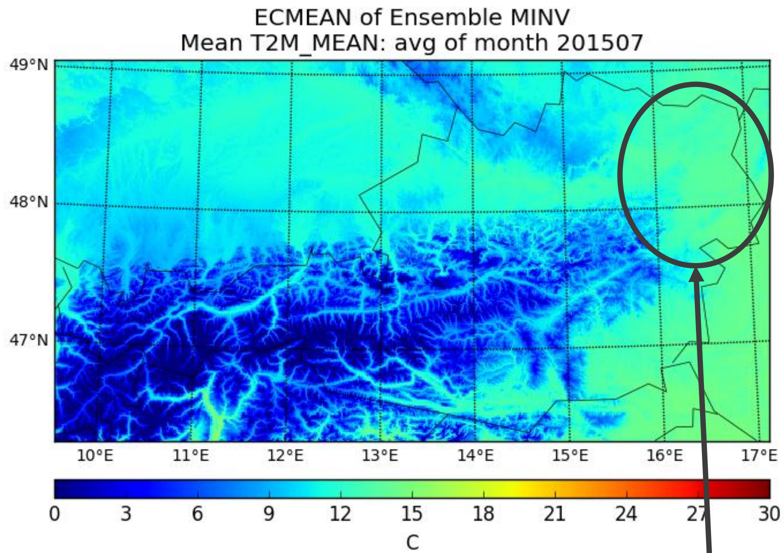
Predictability of the hot and dry episodes

ADA Symposium
04.11.2015

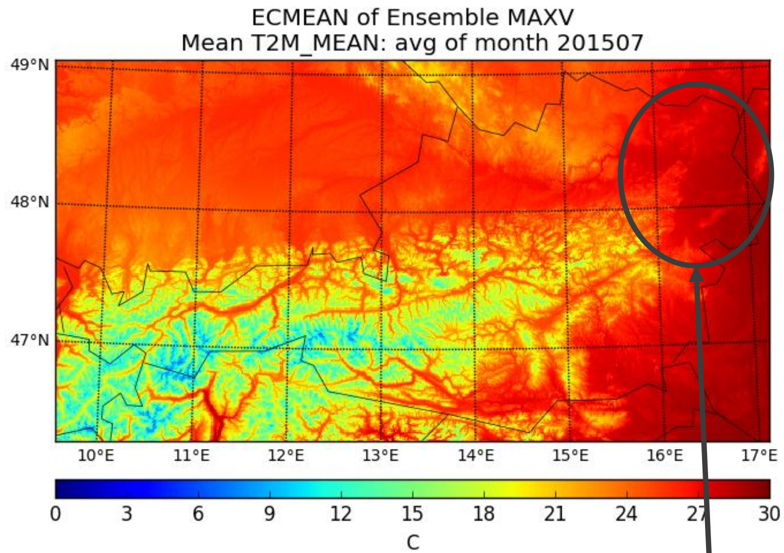
Seasonal forecasts: Initial time January 2015 – Range of temperature forecasts for July (+7 months forecast)

Member with minimum mean 2m temperature



Approx. 15°C

Member with maximum mean 2m temperature



Approx. 28°C

Minimum and maximum forecasts unrealistic cold/hot?

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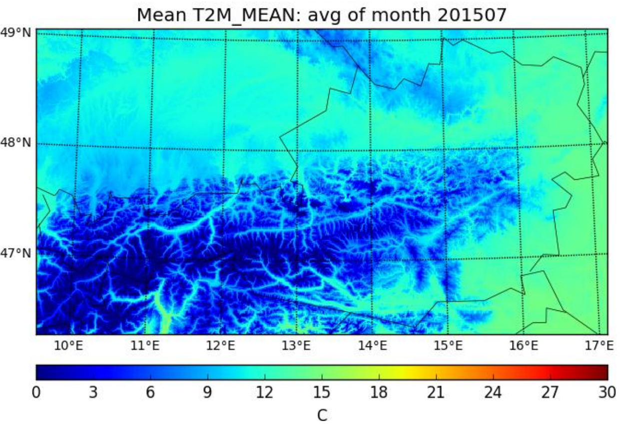
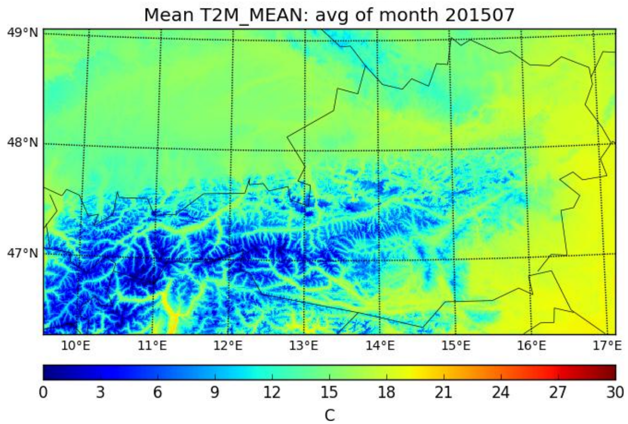
Predictability of July temperatures – Fcst from Jan 2015

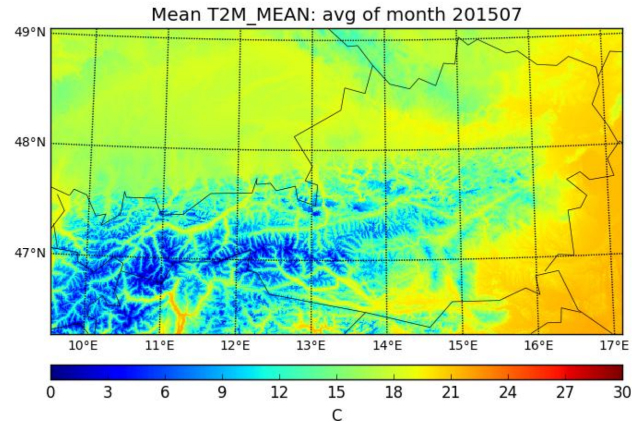
Ensemble minimum



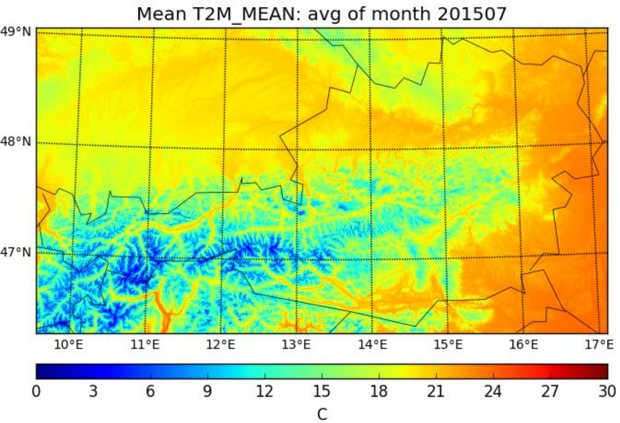
25% percentile



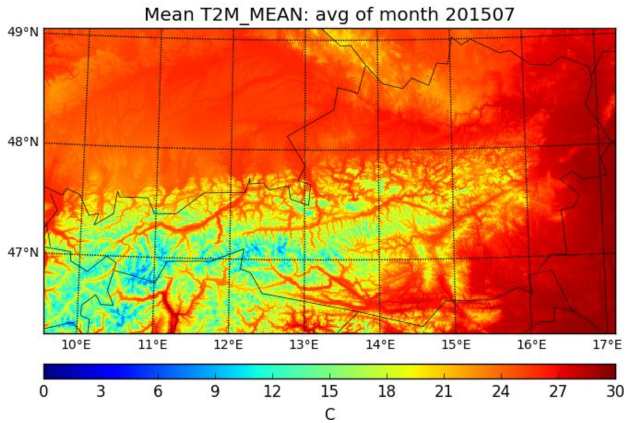
Ensemble mean



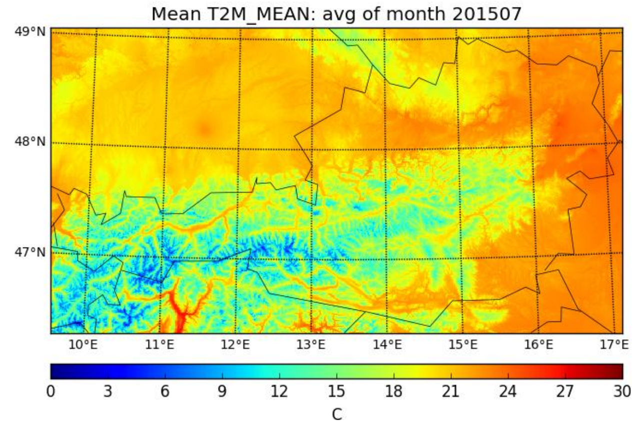
75% percentile



Ensemble maximum



INCA analysis



75 percentile seems to capture the hot temperatures well

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Thanks for attention!