Zentralanstalt für Meteorologie und Geodynamik

Detection of convective initiation by objective analysis methods and its use for precipitation nowcasting

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Translational nowcasting:

- Convective situations = biggest challenge!
- Translational nowcasting cannot account for development of precipitation fields
- Can a simulation of convective life cycle improve nowcasts?

⇒ Convective nowcasting!

Data material:

- Analysis fields of convective indices (Δx = 1 km, Δt = 1h) provided by the INCA system („Integrated Nowcasting through Comprehensive Analysis"; Haiden et al., 2011)
- „First guess" either from ALADIN (Δx = 9.6 km), ALARO (Δx = 5 km) or AROME (Δx = 2.5 km) forecasts
- Correction by latest station measurements

Methodology

Convective nowcasting:

For each „convective gridpoint“ (i.e., with CAPE > 50 J/kg within a certain radius) on 1x1 km INCA grid:

- Convective initiation?
- Intensification of precipitation?
- Weakening of precipitation?

Convective initiation:

$$CAPE > 100\,J/kg$$
$$MOCON > 2\cdot 10^{-6}\,/\,s$$
$$cloudiness > 0.5$$
$$|CIN| < 200\,J/kg$$
$$T - T_{trig} > -2K$$

Intensification of precipitation:

$$CAPE > 50\,J/kg$$
$$MOCON > 2\cdot 10^{-6}\,/\,s$$
$$rain\ rate > 0.2\,mm/h$$
$$|CIN| < 200\,J/kg$$
$$T - T_{trig} > -2K$$

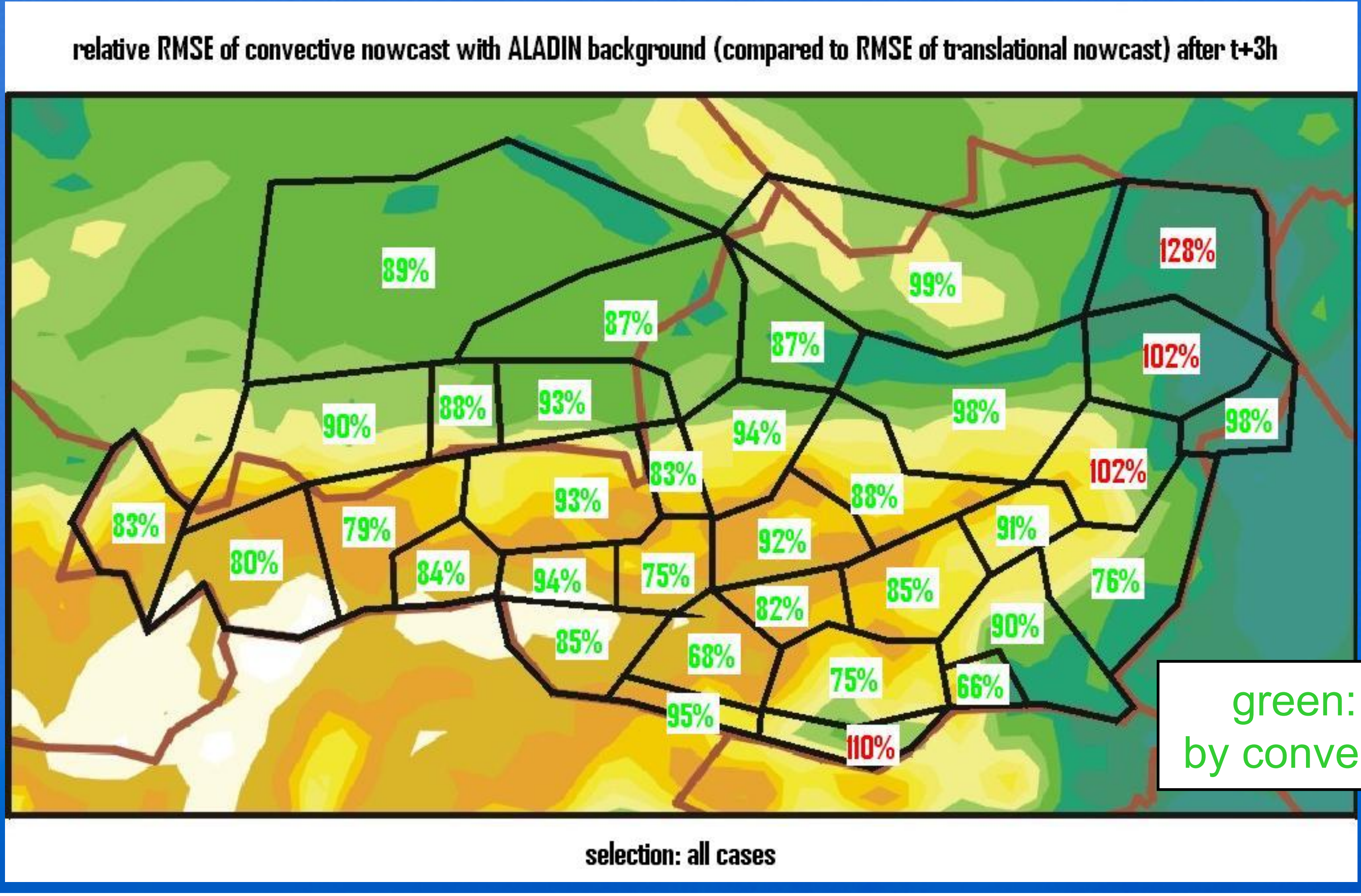
Weakening of precipitation:

$$CAPE < \min\left(\overline{CAPE}^{>0}, 100\,J/kg,\right.$$
$$MOCON < 0\,/\,s$$
$$rain\ rate > 0.0\,mm/h$$

Further assumptions:
- maximum *actual* precipitation intensity: Gaussian bell as a function of time
- maximum *possible* precipitation intensity: function of CAPE and near-surface specific humidity

RMSE of areal precipitation rates:

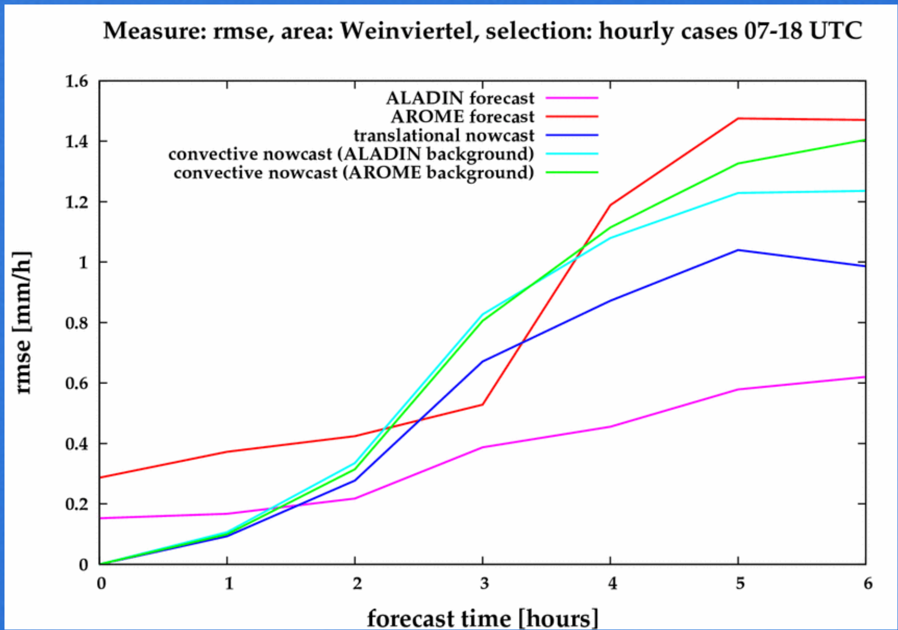
- Convective nowcasts vs. translational nowcasts
- Spatial distribution for t_0+3h (32 selected convection days)

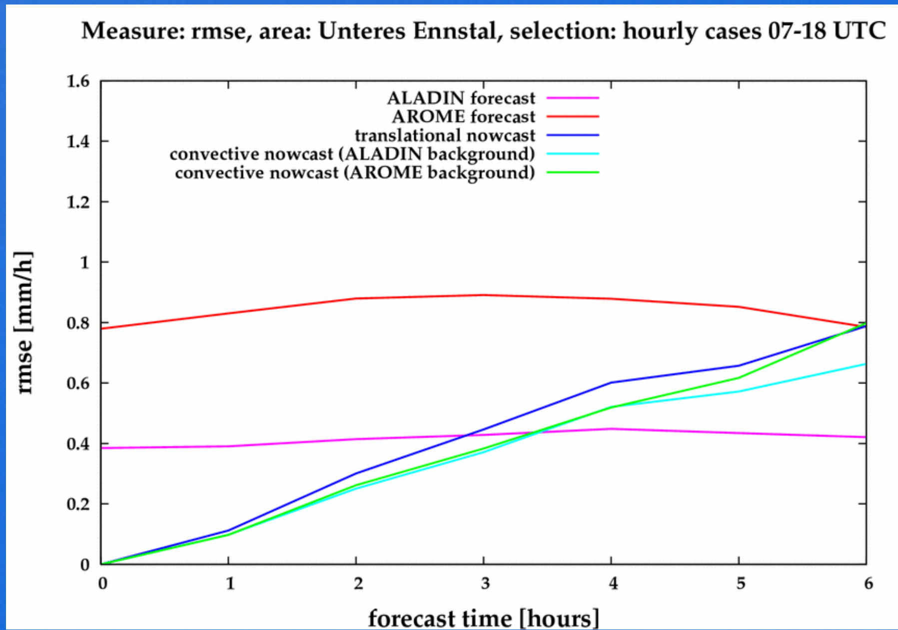


green: improvement
by convective nowcast

RMSE of areal precipitation rates:

- Nowcasts vs. NWP models
- Temporal course for two selected areas (hourly dates 07-18 UTC)





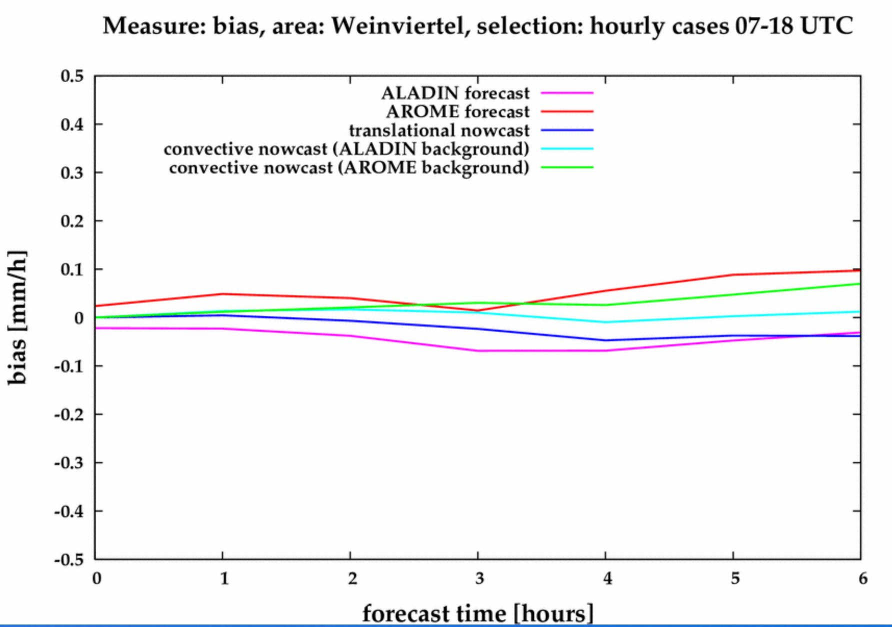
Example for an extra-Alpine area:
- Convective nowcasts worse than translational nowcasts
- Intersection with ALADIN at ~ t_0+1.5h

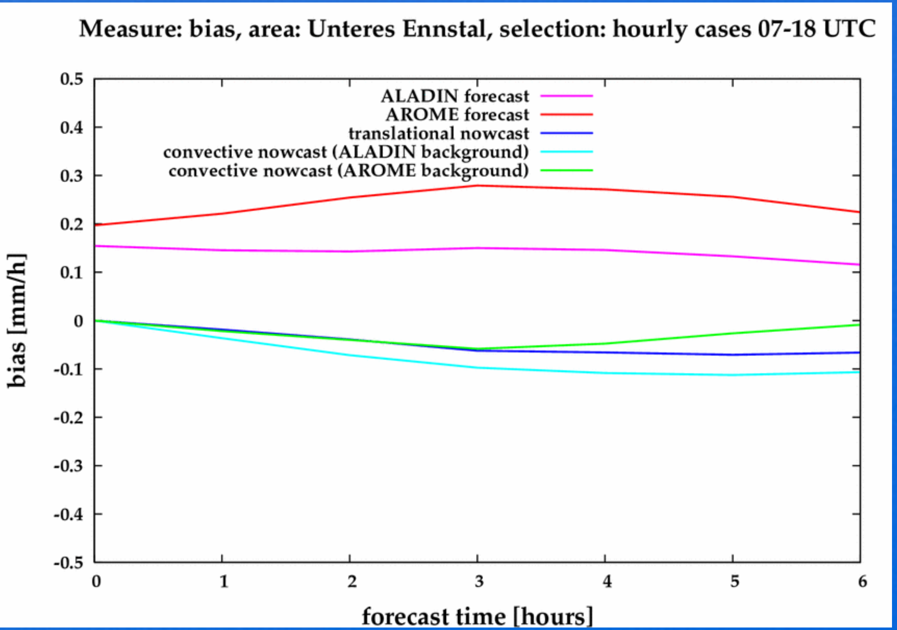
Example for an Alpine area:
- Convective nowcasts better than translational nowcasts
- Intersection with ALADIN at ~ t_0+3h

Verification (3)

BIAS of areal precipitation rates:

- Nowcasts vs. NWP models
- Temporal course for two selected areas (hourly dates 07-18 UTC)

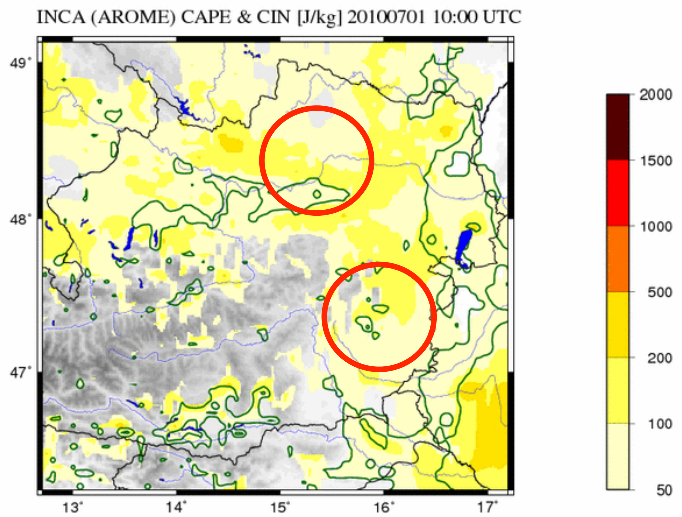


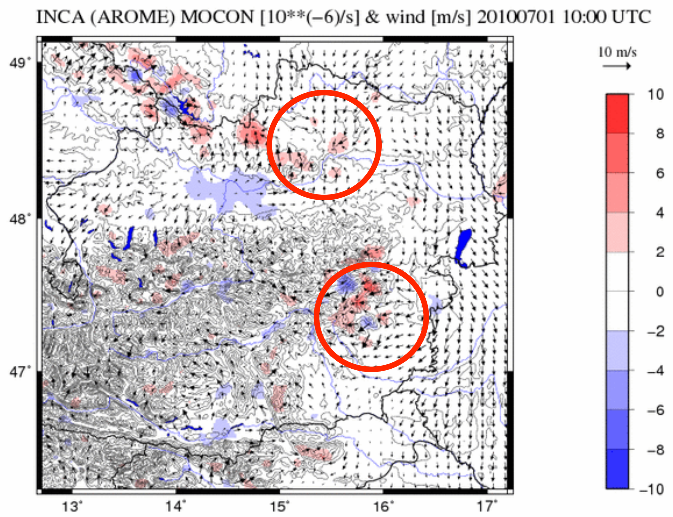


Example for an extra-Alpine area:
- All nowcasts are almost free from BIAS!
- AROME too humid, ALADIN too dry

Example for an Alpine area:
- All nowcasts are almost free from BIAS!
- AROME and ALADIN too humid

Convective analysis fields



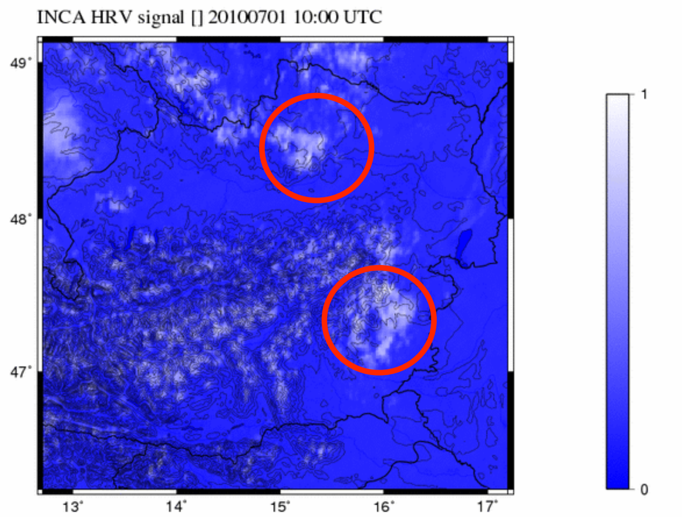


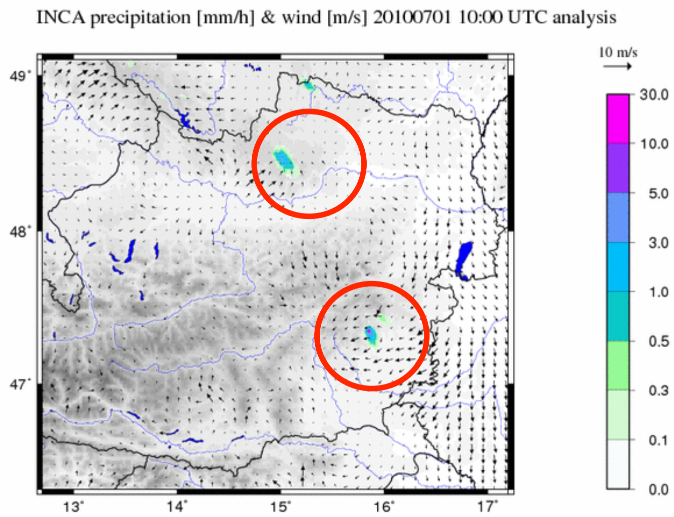
Upper left: CAPE (color shades) & CIN (green contours)

Upper right: 10m wind & moisture flux convergence (MOCON)

Lower left: cloudiness

Lower right: precipitation & 10m wind

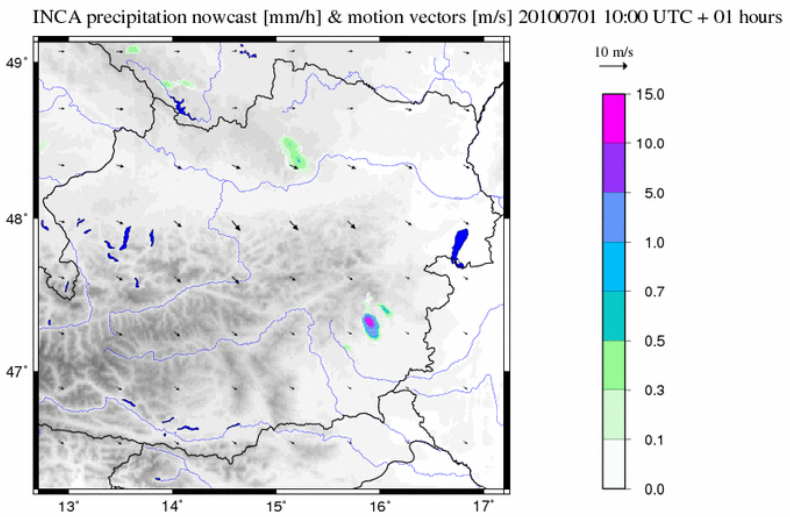




Convective initiation

ECSS 2011
Palma de Mallorca

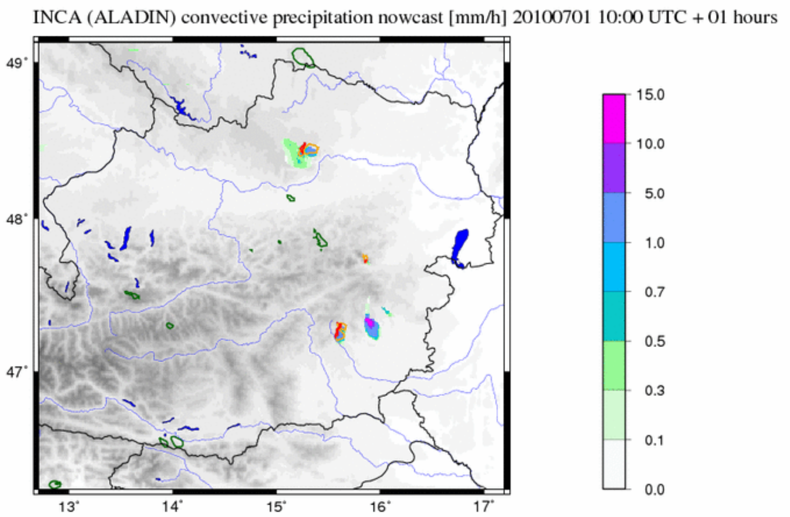
2011-10-07



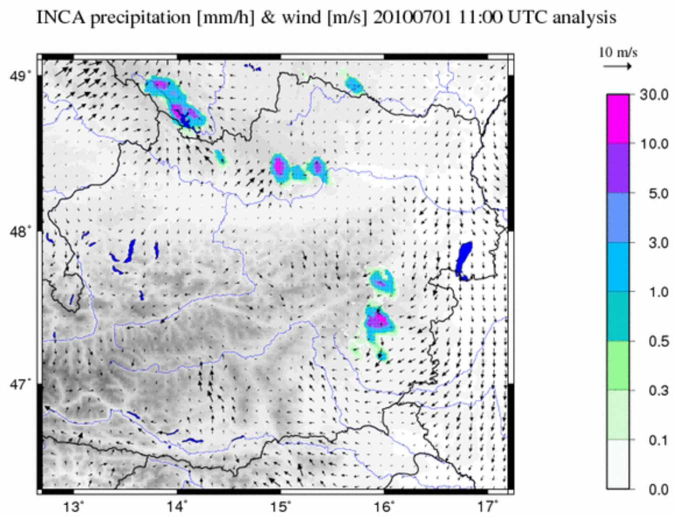
Example I: localized initiation, weak organization 10 UTC 01 July 2010

Upper left: 1-hr translational precipitation nowcast & motion vectors

Lower left: 1-hr convective precipitation nowcast
Red contours: initiation
Orange contours: intensification
Green contours: weakening

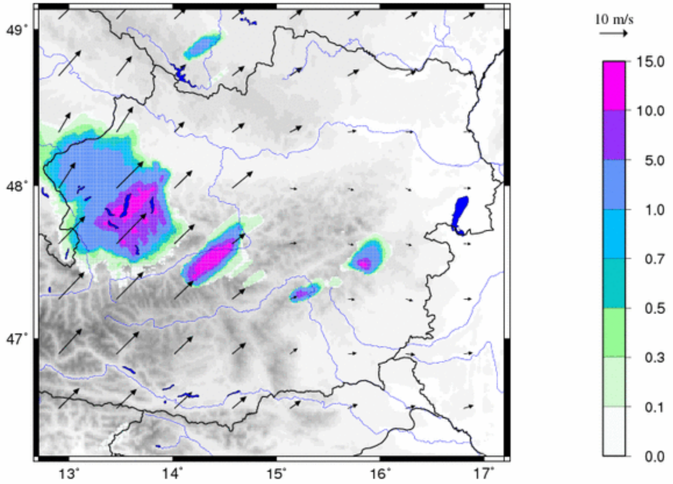


Lower right: precipitation & 10m wind analysis

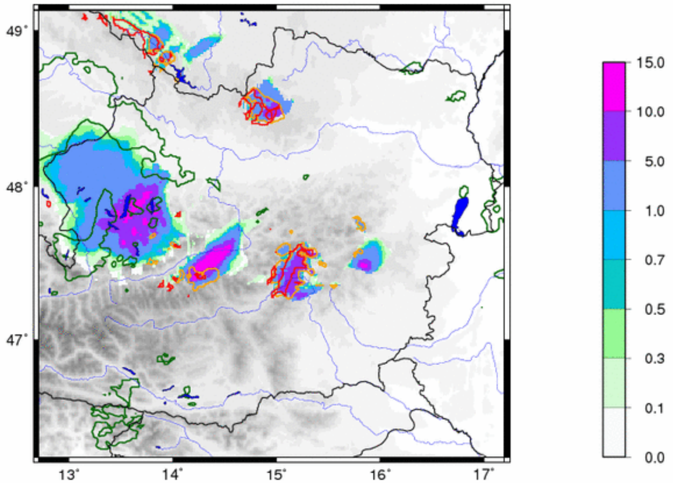


Convective initiation (2)

INCA precipitation nowcast [mm/h] & motion vectors [m/s] 20090715 13:00 UTC + 01 hours



INCA (ALADIN) convective precipitation nowcast [mm/h] 20090715 13:00 UTC + 01 hours



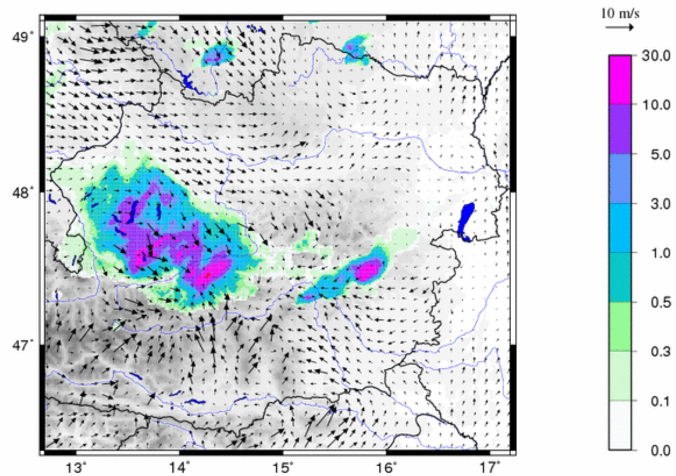
Example II: widespread initiation, weak organization
13 UTC 15 July 2010

Upper left: 1-hr translational precipitation nowcast & motion vectors

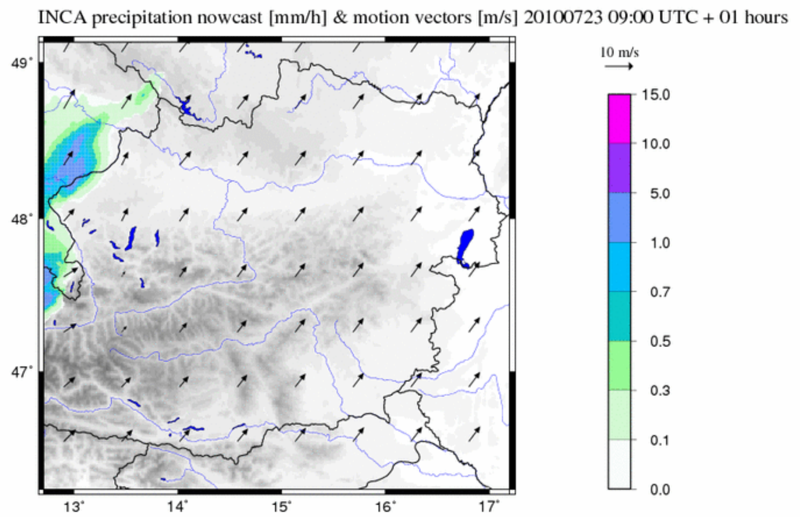
Lower left: 1-hr convective precipitation nowcast
Red contours: initiation
Orange contours: intensification
Green contours: weakening

Lower right: precipitation & 10m wind analysis

INCA precipitation [mm/h] & wind [m/s] 20090715 14:00 UTC analysis



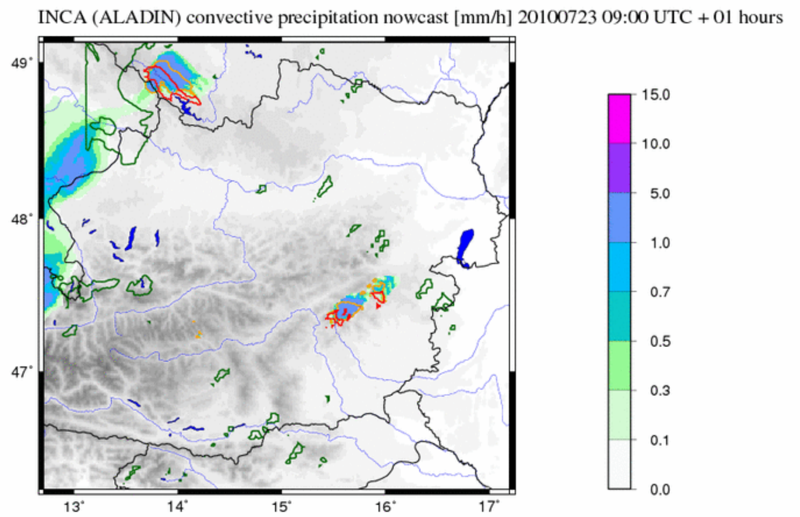
Convective initiation (3)



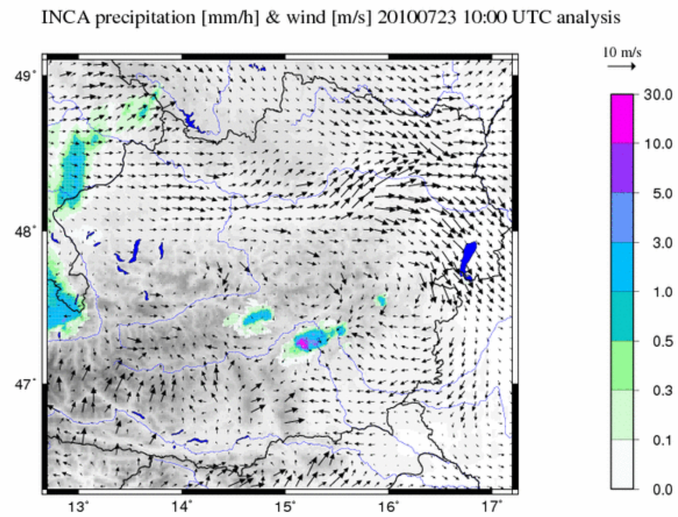
Example III: localized initiation, strong organization
09 UTC 23 July 2010

Upper left: 1-hr translational precipitation nowcast & motion vectors

Lower left: 1-hr convective precipitation nowcast
Red contours: initiation
Orange contours: intensification
Green contours: weakening

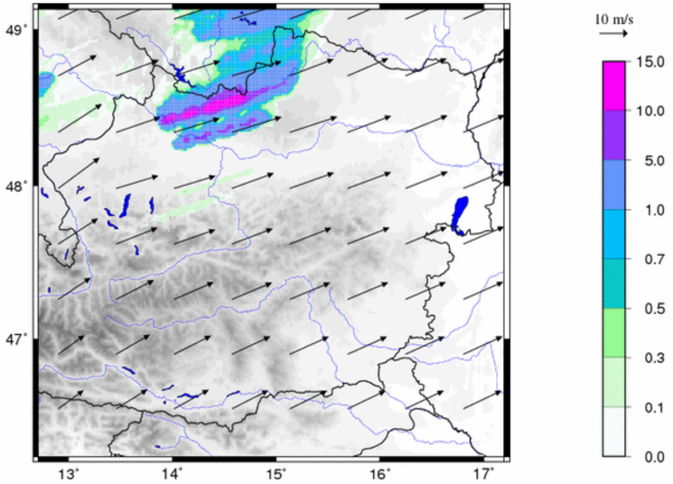


Lower right: precipitation & 10m wind analysis

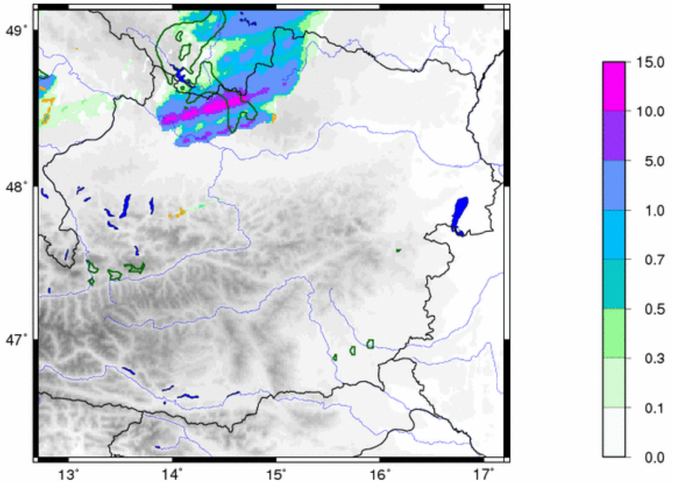


Convective initiation (4)

INCA precipitation nowcast [mm/h] & motion vectors [m/s] 20090723 16:00 UTC + 01 hours



INCA (ALADIN) convective precipitation nowcast [mm/h] 20090723 16:00 UTC + 01 hours



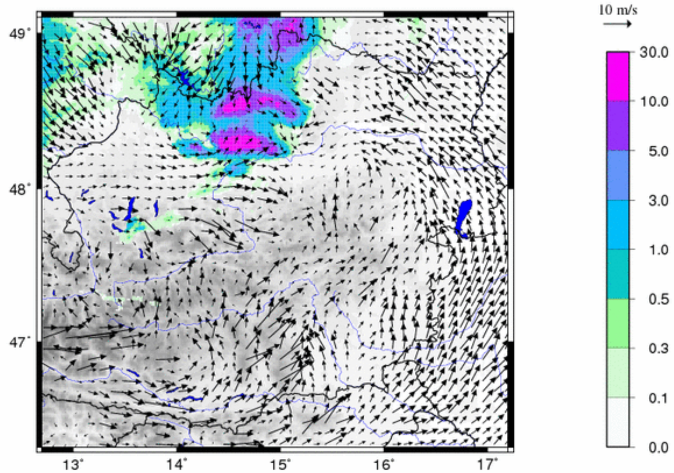
Example IV: widespread initiation, strong organization
16 UTC 23 July 2009

Upper left: 1-hr translational precipitation nowcast & motion vectors

Lower left: 1-hr convective precipitation nowcast
Red contours: initiation
Orange contours: intensification
Green contours: weakening

Lower right: precipitation & 10m wind analysis

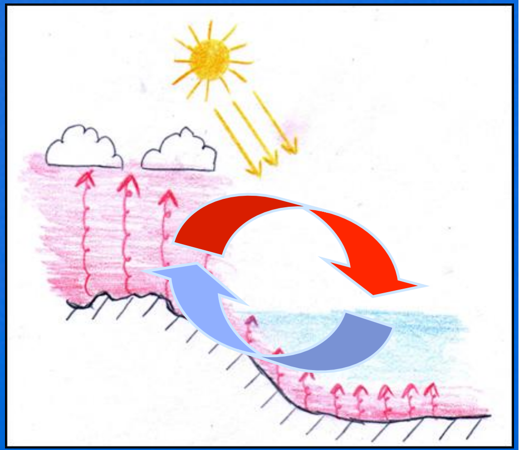
INCA precipitation [mm/h] & wind [m/s] 20090723 17:00 UTC analysis



Primary convection vs. Secondary convection:

- Over Alpine terrain: predominantly „primary convection“
  - + Quick diurnal heating
  - + No significant CIN
  - + Triggered by orographic features

- Over forelands: predominantly „secondary convection“
  - + Compensatory subsidence caps boundary layer
  - + Significant CIN
  - + Triggered by gust fronts, convergence lines and other forms of forced ascent

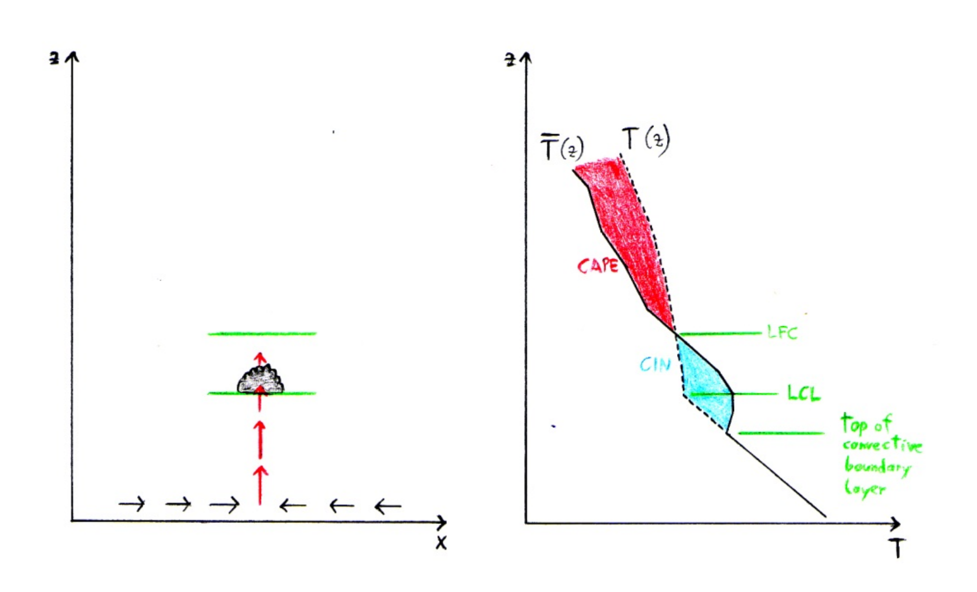


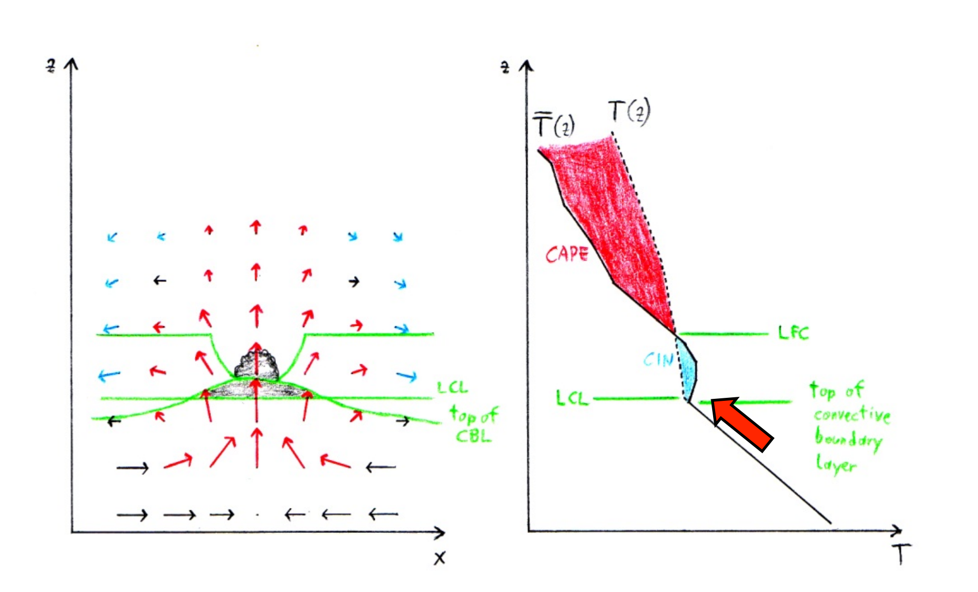
⇒ How does convection in the presence of significant CIN „work“?

Convective initiation (6)

Left:
Convective initiation in the presence of significant CIN according to „parcel theory“

Right:
Convective initiation in the presence of significant CIN in reality





=> Profiles of environmental air are modified by forced vertical motions!

Convective initiation (7)

Examples for forced ascent in the vicinity of existing, well-organized thunderstorms

Results:

- Convective nowcasts are 10-20% better than translational nowcasts over Alpine terrain, slightly worse over the Alpine forelands
- No overall improvement for higher resolution of background fields (ALARO or AROME), but it makes convective nowcasts more „reactive“
- All nowcasts are better than NWP forecasts in the first 2-3 hours and almost BIAS-free

=> Operational implementation of convective nowcasting scheme in 2012!

- Convective initiation: The more difficult to handle, the more widespread it gets and the stronger the synoptic-dynamic support is

Outlook:

- Include further data sources into INCA analysis fields (e.g. satellite data, velocity data of Doppler radar scans)
- Closer tie of convective nowcasting algorithm to physics, especially introduction of dynamic thresholds for CAPE, CIN und MOCON
- Use also forecast fields instead of analysis fields of convective indices
- Representation of simple boundary layer dynamics => interaction and feedback between 3D wind field and vertical profiles of temperature and humidity
- Further research on convective initiation and sustenance

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Thank you for your attention!