

Enhanced use of Radar and Satellite data within the INCA Analysis and Nowcasting System

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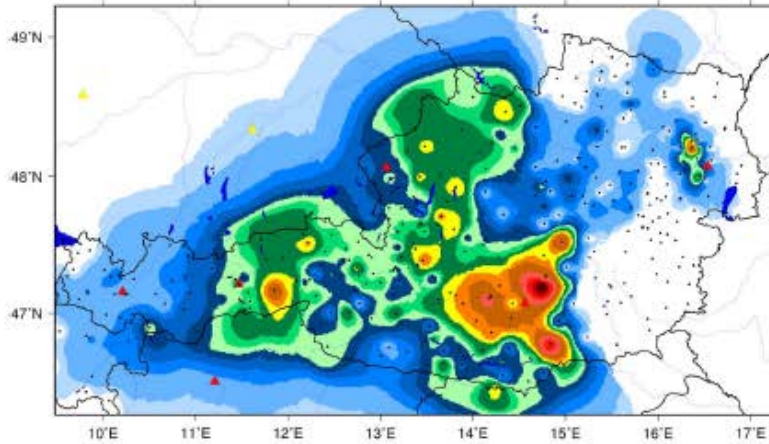


ZAMG
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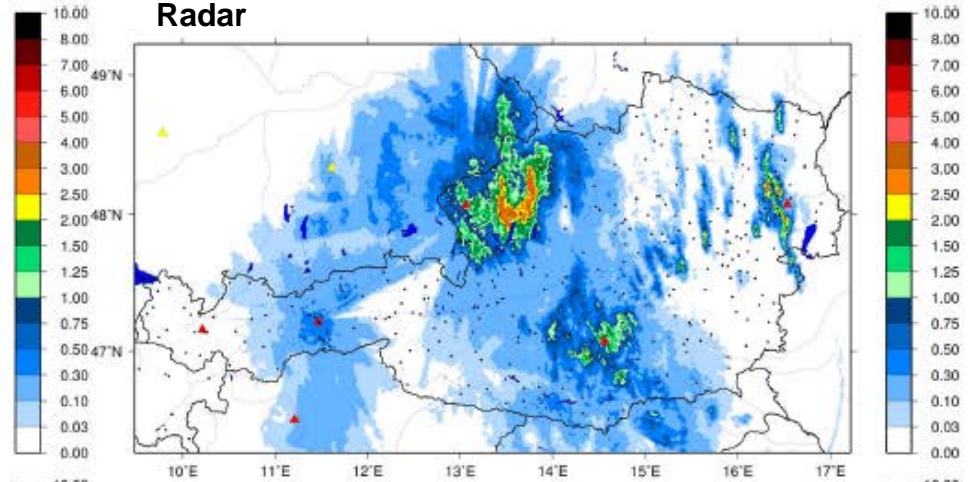
1. Precipitation analysis and nowcasting in INCA
2. Object oriented nowcasting based on *radar data*
 - A-TNT
 - Merging of INCA and A-TNT
 - Validation
3. Use of *satellite data* for analysis and nowcasting in INCA
 - Overview of satellite based rainfall products
 - Evaluation of products
 - SAT-INCA: Analysis and Nowcasting
 - Validation and comparison with NWP

INCA precipitation analysis

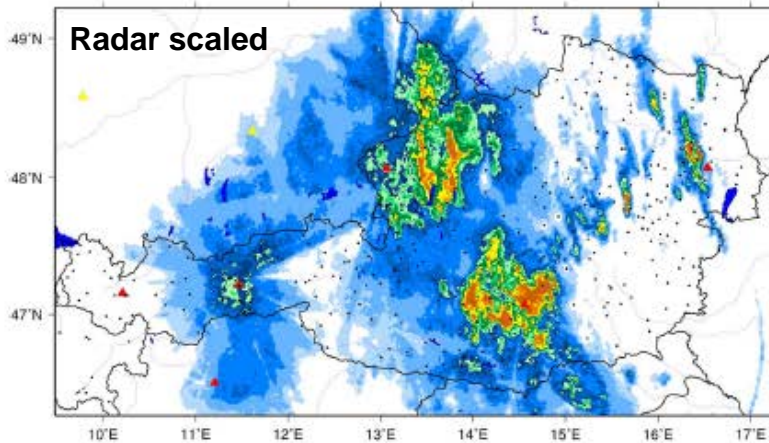
Station interpolation



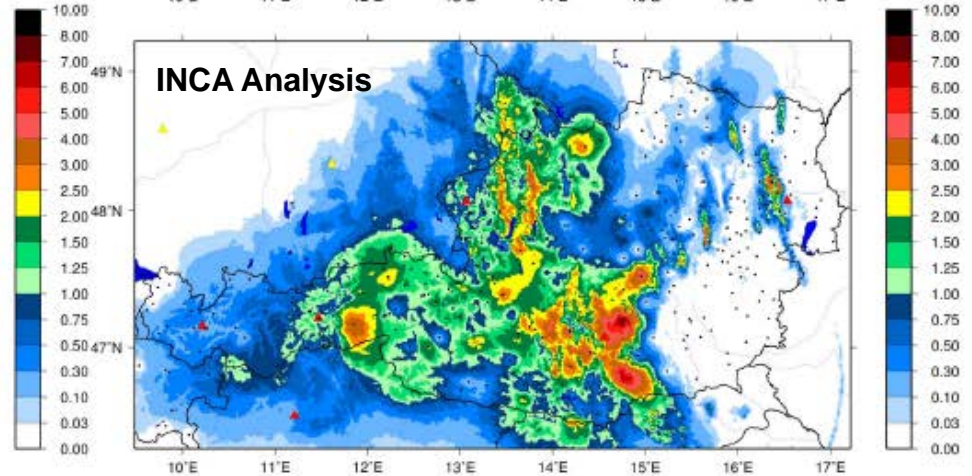
Radar



Radar scaled



INCA Analysis



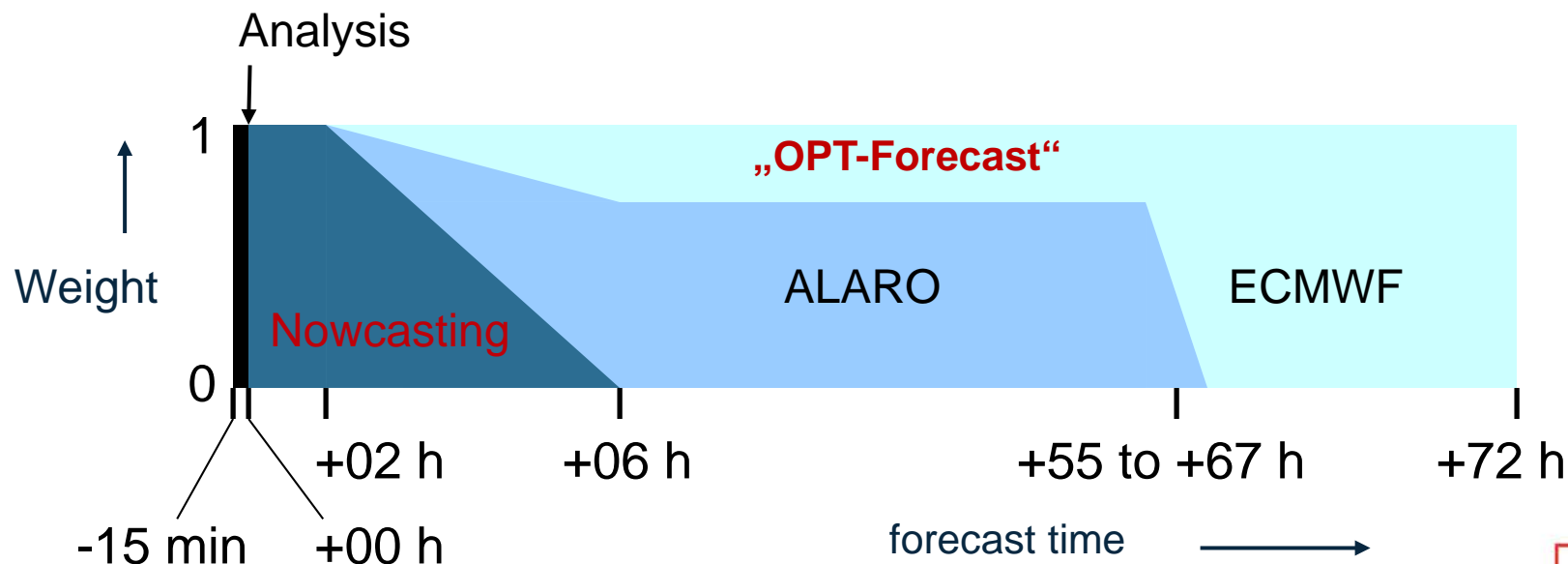
INCA precipitation nowcasting based on motion vectors

Blending with NWP



Nowcasting of precipitation is crucial to add value to NWP within the first forecast hours

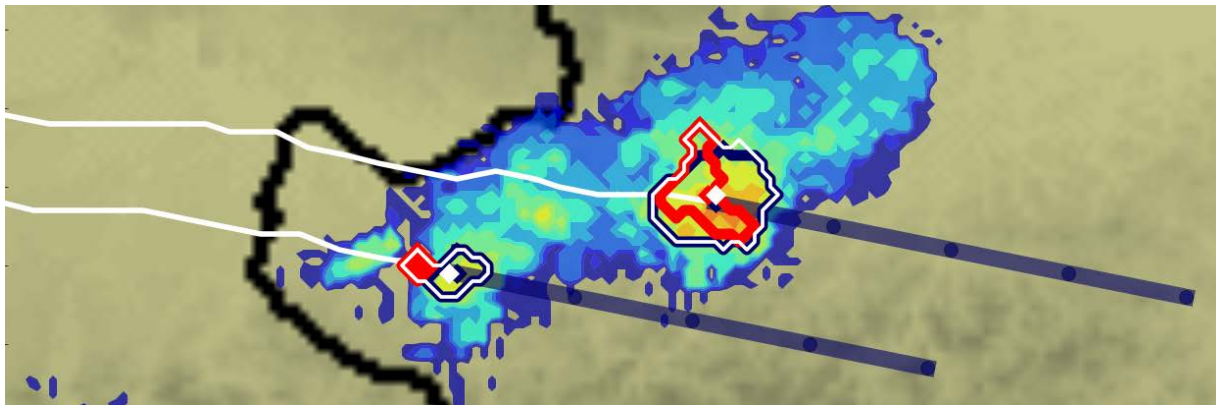
- Motion vectors computed from two consecutive analyses
- Plausibility check with NWP 700 and 500 hPa wind field
- Extrapolation of precipitation analysis



Object-oriented nowcasting using A-TNT

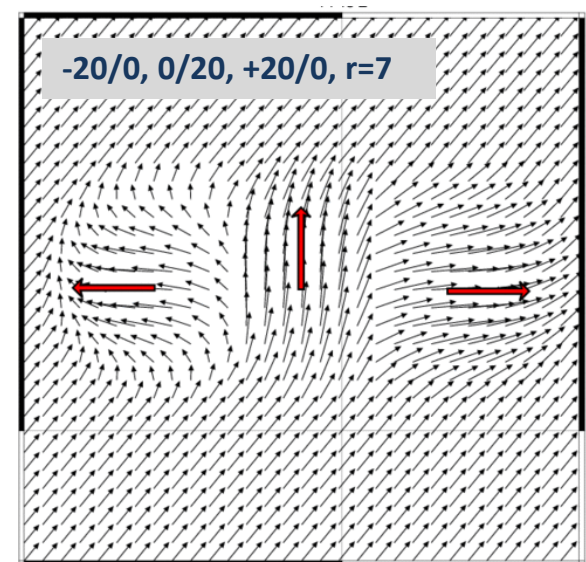
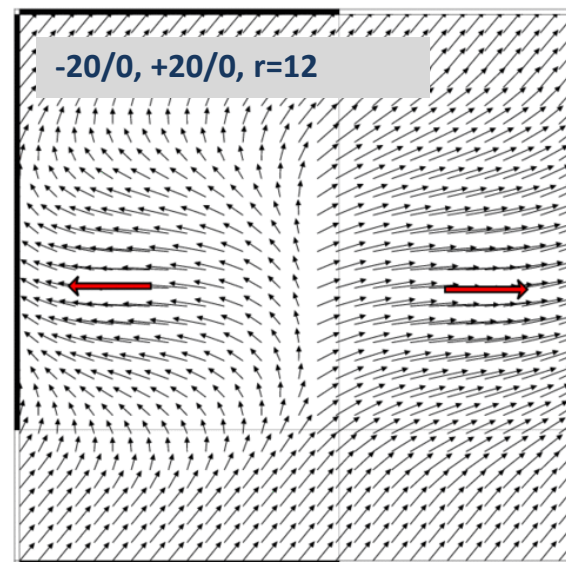
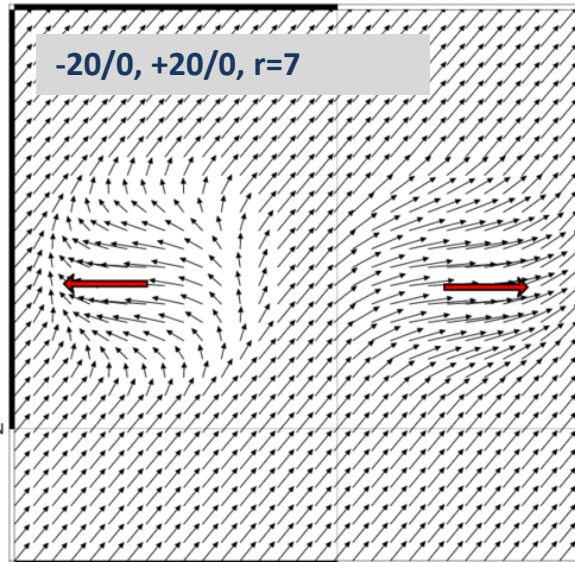
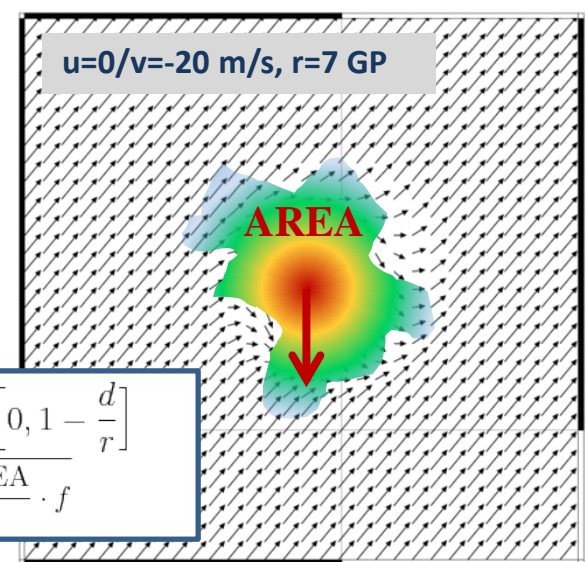
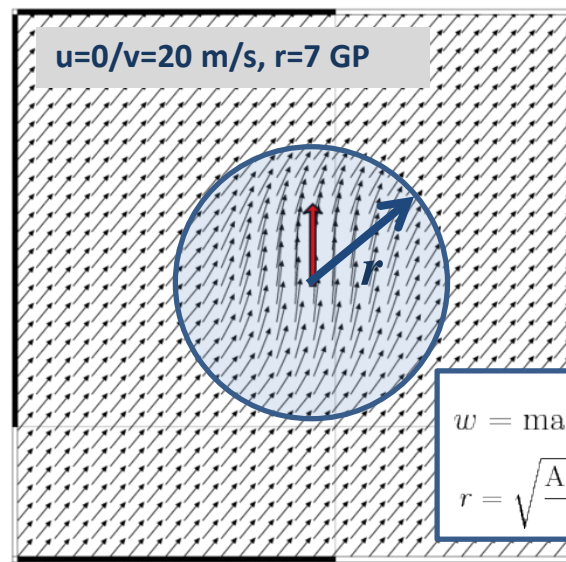
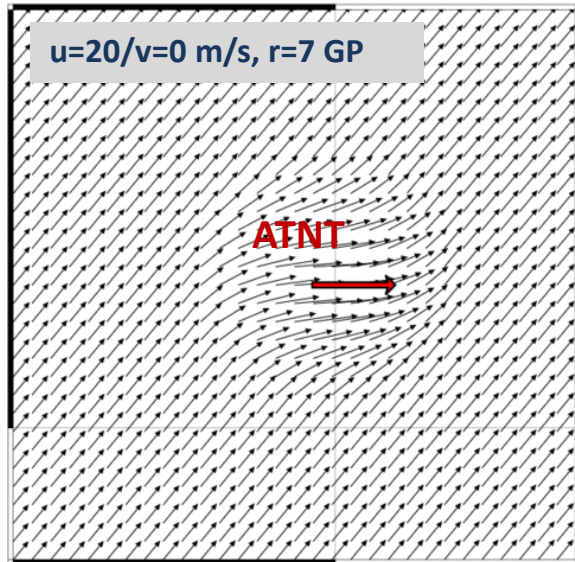
(The Austrian Thunderstorm Nowcasting Tool)

- Object-oriented individual identification, tracking and nowcasting of convective cells
- Cell identification using radar and lightning data
- Radar and lightning cells are assigned using spatially overlapping regions of contemporaneous cells



- Relevant information for INCA:
 - cell ID
 - cell position
 - displacement (vector and velocity)
 - cell area and its change

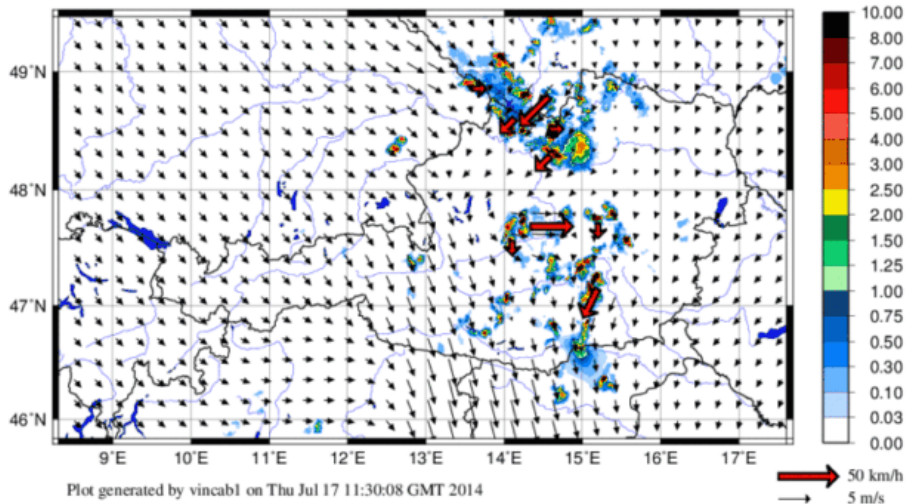
Superposition of ATNT vectors and motion vectors in INCA



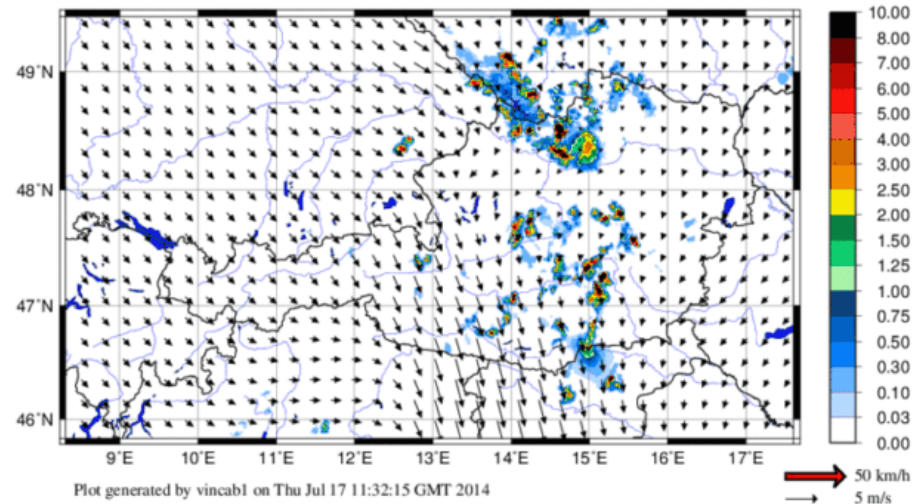
INCA + ATNT vs. Conventional Nowcast



INCA_L 15min RRCT precipitation [mm] 17.07.2014 11:15 UTC + 000 min



INCA_L 15min RR precipitation [mm] 17.07.2014 11:15 UTC + 000 min

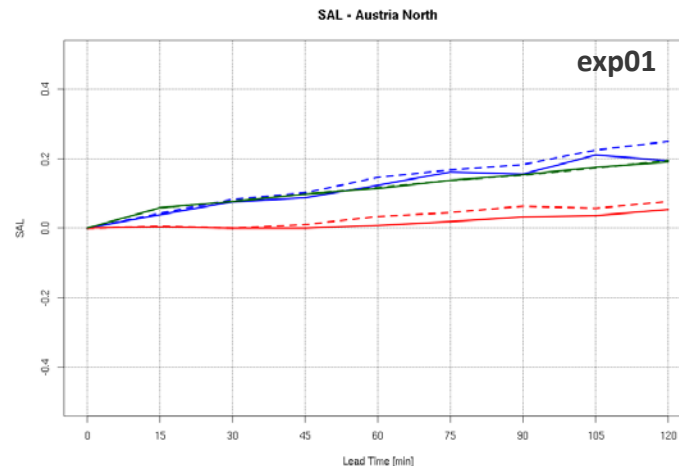


Evaluation

- Rerun time frame: 2015/04/01–2015/06/30 and 2014/07/01–2014/07/31, daytime only, 06–23 UTC
- INCA field, ATNT vectors and motion vectors must be available

Experiment	n_vec	rr_max	Cell Size	Propagation speed	Radius of Influence
exp01	> 6	> 8 mm			depending on cell size
exp02	> 6	> 8 mm			50 km
exp03	-	-	> 1000 px		depending on cell size
exp04	-	-	> 1500 px		depending on cell size
exp05	-	-	> 750 px		depending on cell size
exp06	-	-	-	> 15 px/fc_time	depending on cell size
exp07	-	-	-	< 15 px/fc_time	depending on cell size

- Verification: SAL (Wernli et al., 2008)
- Regions: Austria ALL, Center, Southeast, North, Northeast, West, South



Satellite based precipitation products

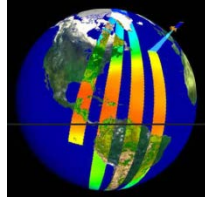
Low Earth Orbit (LEO)

Latency: > 3-4h

Interval: 1-2d

Instruments: AMSR, AMSU, MHS, SSM/I, SSMIS, TMI, WindSat

Microwave → Hydrometeors



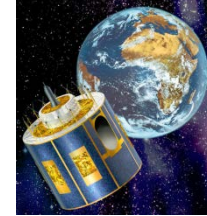
Geostationary Orbit

Latency: 15-60min

Interval: 15-60min

Instruments: SEVIRI (MSG), GOES, ...

IR, VIS, WV → Cloud top



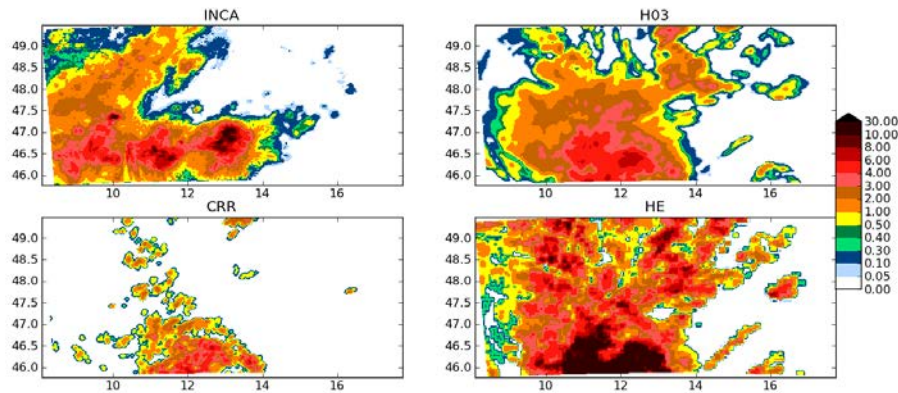
Requirements for Nowcasting

High temporal resolution (<1h), High spatial resolution (on the order of 1 km), continuous observations.

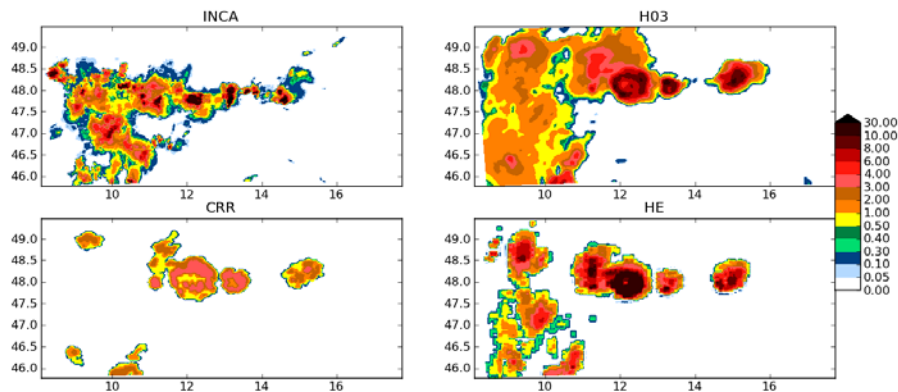
Product name	H03	CRR (Convective Rainfall Rate)	HE (Hydro Estimator)
Provider	HSAF (EUMETSAT)	NWCSAF(EUMETSAT)	NOAA
Spatial Res.	8km	8km	5km
Temporal Res.	15min	15min	1h (Europe)
Characteristics	IR+MW	IR, VIS, WV (SEVIRI)	based on IR (GOES, SEVIRI)
Reference	http://hsaf.meteoam.it	http://www.nwcsaf.org/	http://www.star.nesdis.noaa.gov

Validation of precipitation products

- 11 days with heavy precipitation from 2012 and 2013
- H03, CRR, HE interpolated onto INCA grid (1 km)
- Reference: INCA analyses



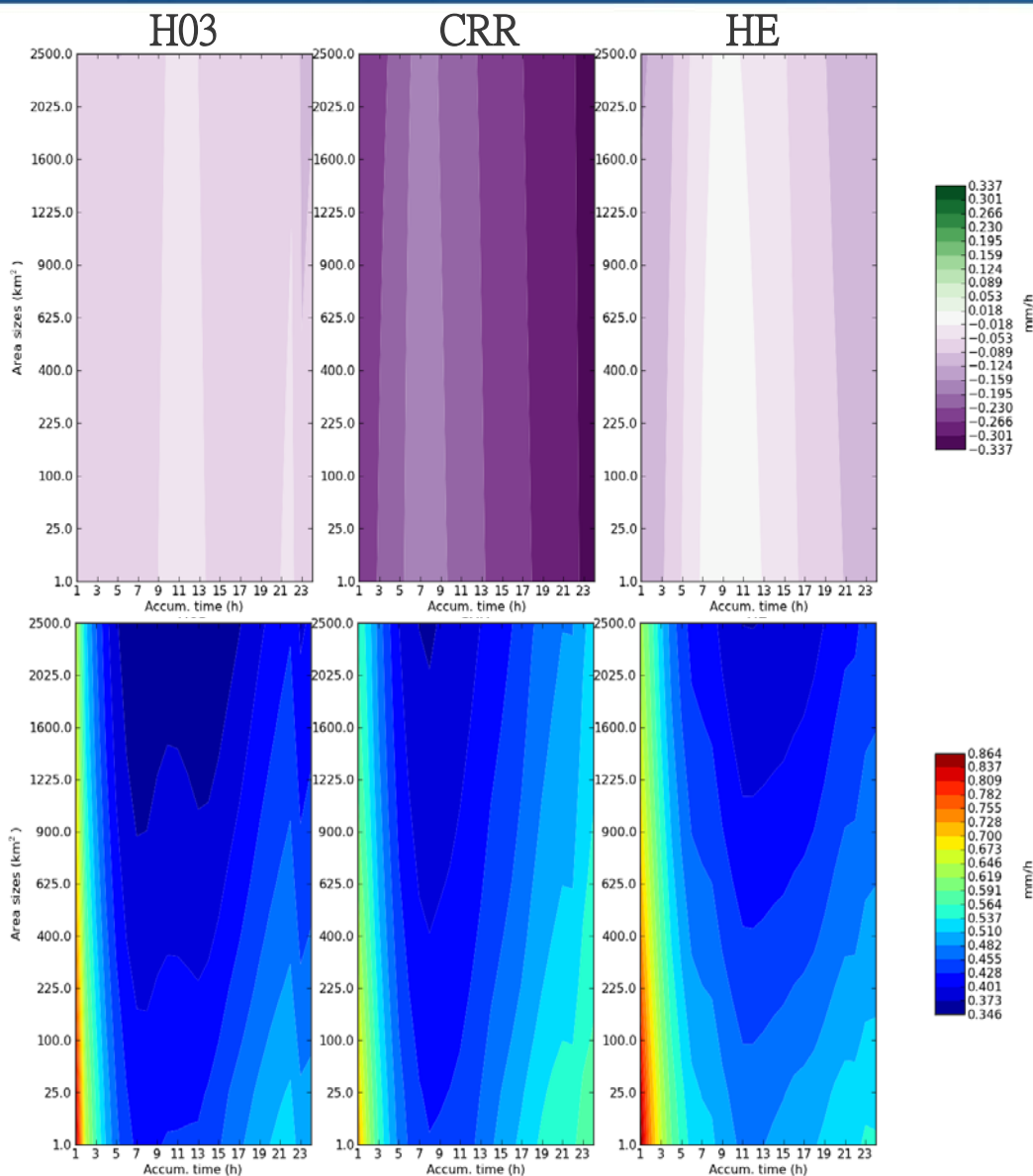
20121111 08 UTC
Stratiform precipitation



20120704 20 UTC
Convective precipitation

- Verification: Bias, RMSE, SAL

Validation results



BIAS (accumulation period, domain size)

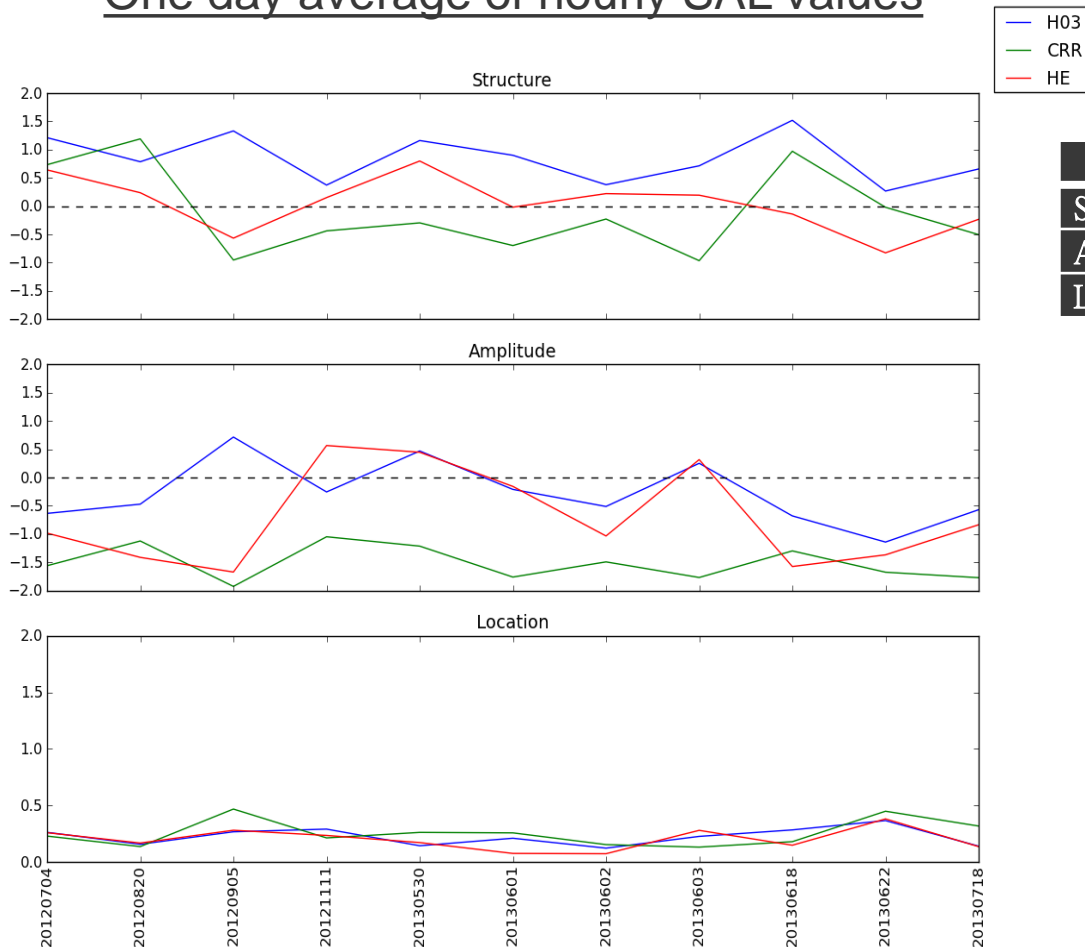
- Strongest underestimation by CRR
- Not dependent on domain size
- Short and large accumulation periods lead to largest error

RMSE (accumulation period, domain size)

- Short accumulation period (up to +5h) leads to large error
- CRR relatively good with short accumulations (better do not forecast anything than forecast at much precipitation at wrong position - double penalty)
- H03 and HE quite similar

Validation results

One day average of hourly SAL values



Mean over all SAL values

	H03	CRR	HE
Structure	0.85	-0.11	0.04
Amplitude	-0.28	-1.50	-0.70
Location	0.22	0.25	0.20

- Structure: H03 does not capture structures well. HE performs best.
- Amplitude: CRR underestimates the amplitude significantly.
- Location: All the same...

Evaluation of satellite products

- CRR underestimates precipitation significantly (amplitude)
- On average, H03 gives best quantitative forecasts (bias, amplitude)
- HE quite similar to H03 but with stronger variation of data (not shown)
- H03 has higher time resolution (15 min instead of 1h)
- H03 selected

In general, the accuracy of HR (time and space) precipitation estimates from satellite data is not always satisfactory when compared to radar and raingauge data

Nevertheless it provides important input for analysis and nowcasting purposes.

Analysis and nowcasting based on satellite data („SATIN“-Project)

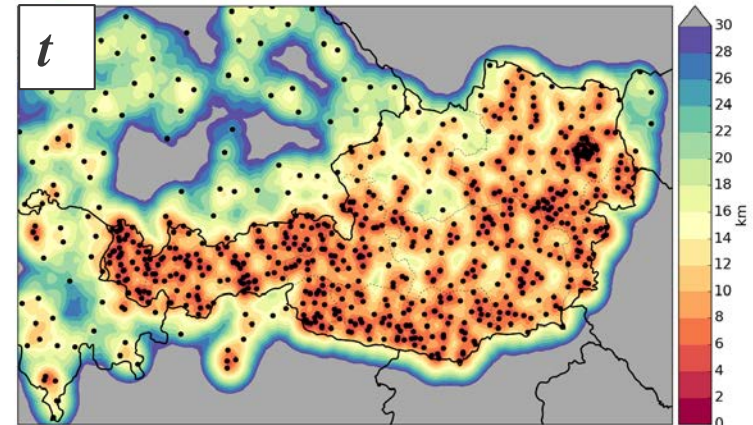
Analysis: Combination of satellite precipitation and raingauges

- Both satellite and raingauge data is interpolated onto the INCA grid (IDW, $1/r^2$, 8 NN)
- For each grid point, the mean distance t to the nearest three stations is computed
- Computation of a weighting factor for the combination of satellite data and raingauges with logistic function

$$RR = w(RR_{SAT}) + (1 - w)RR_{STAT}$$

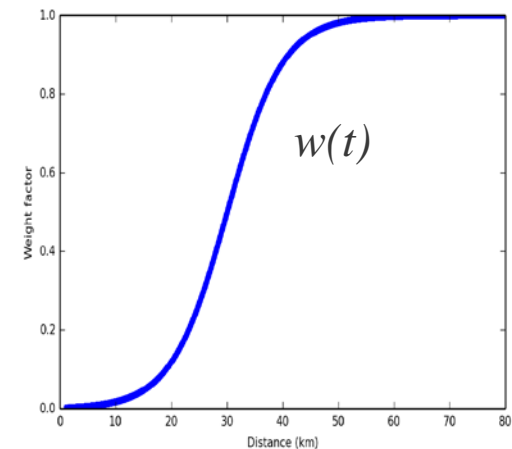
$$u = 30 \text{ km}$$

$$w = \frac{1}{1 + \exp(k(t - u))}$$

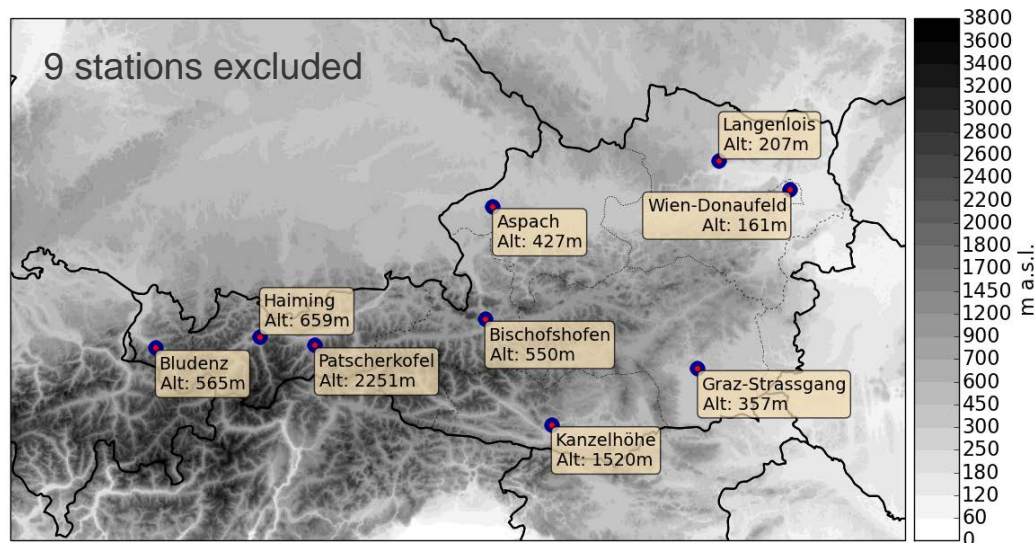


Nowcasting: Motion vectors are computed from last few satellite precipitation fields

- Computation similar to normal INCA approach, based on correlations
- Interpolation of motion vectors onto INCA grid, using a time average
- Pure Nowcasting, no blending into NWP

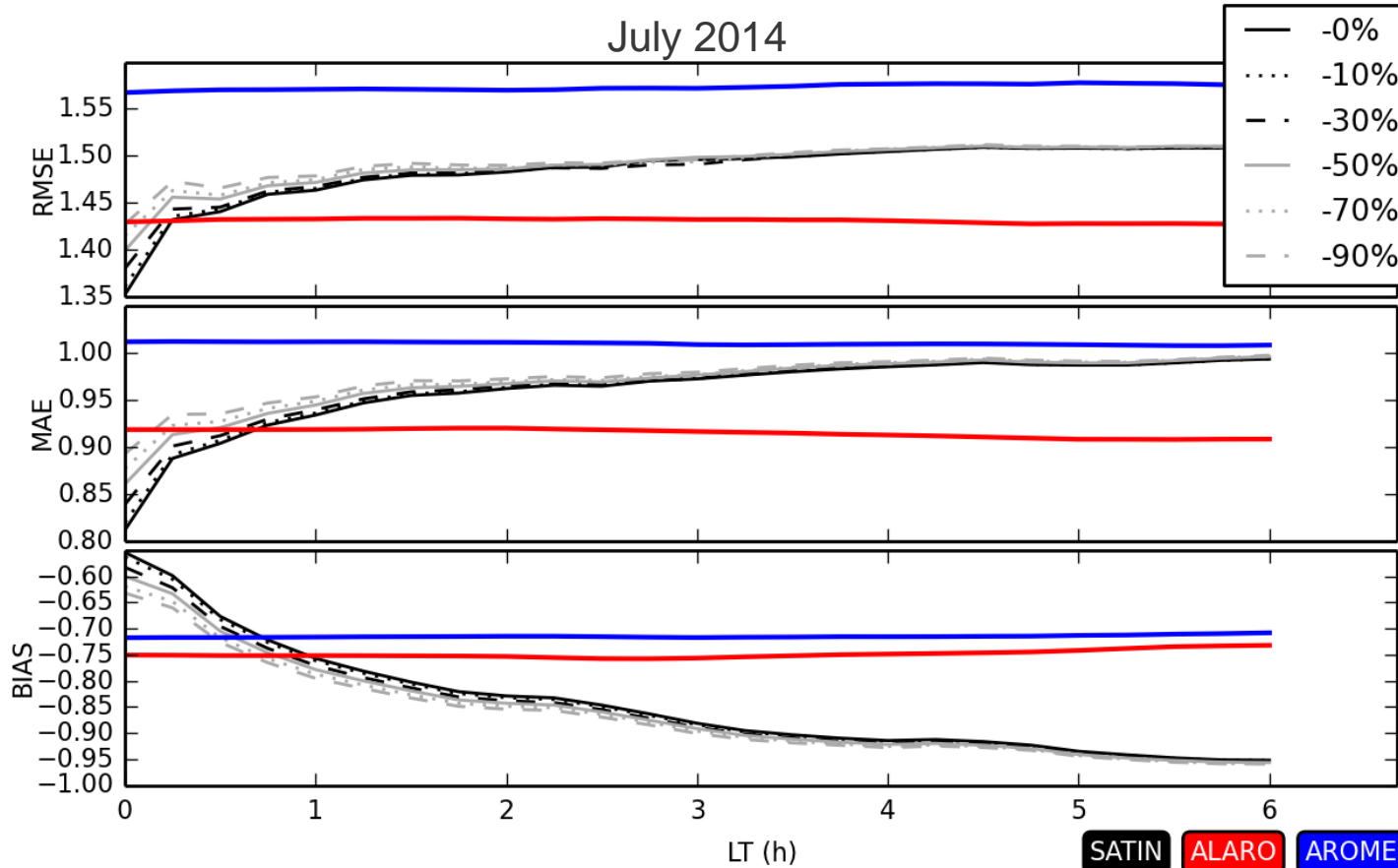


Analysis verification: Cross Validation



	January 2014			July 2014		
	ALARO5	H03	SATIN	ALARO5	H03	SATIN
RMSE	0.86	1.12	0.71	1.26	1.58	0.99
MAE	0.72	0.99	0.6	0.89	1.19	0.64
Bias	-0.52	-0.87	-0.45	-0.76	-0.39	-0.35

Nowcast verification



- Forecast fields vs. INCA (all gridpoints with non-zero precipitation)
- N % of stations were removed from SATIN analyses
- The analysis quality is most affected, but the influence of reduced station density is decreasing with longer lead times
- SATIN performs better than NWP within the first hour, even with the number of stations reduced

Summary and conclusions

- Nowcasting of precipitation is crucial to add value to NWP within the first forecast hours. Object oriented approaches offer alternative way for nowcasting and warnings.
- Simple displacement (motion vectors) may fail for individual situations but is hard to beat on average.
- Combination of INCA + ATNT has the potential to improve nowcasts, but further work is needed, e.g.
 - import cell borders and area trend in INCA
 - include intensity tendencies
- Raingauge precipitation is underestimated by satellites in most cases
- A combination of satellite precipitation and raingauges provides more accurate precipitation analyses than the fields gained from NWP
- Even with reduced station density, satellite analyses are better than NWP
- Satellite nowcast scores are outperformed by NWP from leadtime 0.5-1h onwards (depending on case/season)
- Satellite precipitation together with rain gauges provides valuable information in regions with insufficient radar coverage
- Even a sparse station network is of value



Thank you !