Minutes of the International RainGain Workshop on fine-scale rainfall estimation

Prepared by Laurens Cas Decloedt and Patrick Willems (KU Leuven)

Date: Monday 16th April 2012, from 9:00 to 21:30

Venue: Arenberg Library Room, CBA Celestijnenklooster, CBA 01.10 Nicolas De le Ville zaal, Willem de Croylaan 6, 3001 Heverlee (Leuven), Belgium

General aim of the workshop:

- Discuss among the scientific project partners and international experts methods and experiences, and prepare guidelines for radar calibration and fine-scale rainfall estimation

Present:

Bruni / Guendalina	TU Delft
ten Veldhuis / Marie-Claire	TU Delft
Sun / Siao	INSA de Lyon, France
Russchenberg / Herman	TU Delft
Delobbe / Laurent	Royal Meteorological Institute of Belgium
Decloedt / Laurens Cas	KU Leuven
Tabary / Pierre	Météo France
Lukach / Maryna	Royal Meteorological Institute of Belgium
Goudenhoofdt / Edouard	Royal Meteorological Institute of Belgium
Paulus / Raphaël	University of Liège
Tchiguirinskaia / Ioulia	Ecole des Ponts ParisTech
Van Steenbergen / Niels	KU Leuven
Giangola-Murzyn / Agathe	LEESU-Ecole des Ponts ParisTech

Van Assel / Johan	Aquafin NV
Kroll / Stefan	Aquafin NV
Reyniers / Maarten	Royal Meteorological Institute of Belgium
Darlington / Tim	UK Met Office
Maksimovic / Cedo	Imperial College London
O'Brien / Barry	UK Local Government Information Unit
Leijnse / Hidde	KNMI
Pineda / Luis	KU Leuven
Borup / Morten	DTU Environment / Krüger A/S (Veolia Denmark)
Ochoa Rodriguez / Susana	Imperial College London
Danielsen Sørup / Hjalte Jomo	Technical University of Denmark, Denmark
Löwe / Roland	Technical University of Denmark, Denmark
Wang / Li-Pen	Imperial College London
Overeem / Aart	KNMI, The Netherlands
Thorndahl / Søren Liedtke	Aalborg University, Denmark
Jensen / Niels Einar	DHI Group, Denmark
Schertzer / Daniel	Ecole des Ponts ParisTech
Gires / Auguste	Ecole des Ponts ParisTech
Uijlenhoet/Remko	Wageningen University
Schellart/Alma	University of Bradford
McLaughlin/David	Univ. of Massachusetts at Amherst
Willems / Patrick	KU Leuven

Programme - International RainGain Workshop on fine-scale rainfall estimation

(chair: Patrick Willems, KU Leuven)

9:00 – 9:30 Arrival and coffee

9:30 – 10:00 Welcome and introduction

10:00 – 11:30 X-band and C-band radar calibration : methods and experiences

11:30 – 12:00 Break

12:00 – 13:00 X-band versus C-band performance : experiences

13:00 – 14:00 Lunch

14:00 – 15:30 Integration of X-band, C-band and rain gauge measurements
: methods and experiences

15:30 – 16:00 Break

16:00 – 17:00 Fine-scale rainfall estimation : recommendations and guidelines

19:00 – 21:30 Dinner

Minutes - International RainGain Workshop on fine-scale rainfall estimation

General organization of the workshop

Rather than organizing the workshop in a classical setting of oral presentations, we decided to have open discussions on the following four topics and related subtopics:

- Topic 1: X-band and C-band radar calibration : methods and experiences

  1.1. calibration of reflectivity, differential reflectivity, differential phase, ... single vs. dual polarization

  1.2. adjustment to rain gauges: useful? methods? experiences?

  1.3. monitoring/maintenance of the radar system (e.g. routine checks of radar parameters & variables)

- Topic 2: X-band versus C-band performance : experiences

  2.1 limitations/differences of X-band and C-band radars in rain rate estimation performance: influence of attenuation, clutter, maximum effective range, detection capability, stability, ...

  2.2 accuracy estimation of rain rate estimation (e.g. taking rain gauge observations as reference?) methods? typical results?

- Topic 3: Integration of X-band, C-band and rain gauge measurements : methods and experiences

  : methods to merge different rainfall products from different sources (X-band, C-band and rain gauges) to come to a most reliable fine-scale rainfall estimate for urban drainage applications

  3.1 mosaicking radars of different wavelengths, with focus on nesting Xpol in Cpol

  3.2 radar - rain gauge merging

- Topic 4: Fine-scale rainfall estimation : recommendations and guidelines

  : here we formulated general conclusions, based on the outcomes from the discussions on topics 1, 2 and 3.

For each of these topics, we discussed methods during 1 to 1.5 hour, and aimed to formulate at the end of the workshop main recommendations, which will be considered by KU Leuven (WP2 leader) to prepare after the workshop a "guidelines" document on fine-scale rainfall estimation. These guidelines will be published after summer 2012, and will be used to steer the WP2 project activities by the RainGain project partners during their project implementation.

All participants very actively contributed to the discussion. Many participants prepared few slides on each/some of the four topics, to show the methods the participant is familiar with and/or to show the experiences in other applications.

Focus of the workshop was on methods to obtain good quality fine-scale rainfall estimates (about 100 meter space scale; about 5-10 minutes time scale) that can serve urban drainage impact modeling. The idea of the workshop was to bring current knowledge together and to organize interfacing of knowledge between meteorologists and urban hydrologists, in order to come up with practical recommendations/guidelines. The focus of the workshop was limited to rainfall estimation (for historical periods) and did not cover real-time forecasting or integration with numerical weather prediction. The latter topic will be for another RainGain workshop later during the project.

The following participants prepared contributions in the form of short presentations to one or more of the workshop themes:

- Laurent Delobbe: Royal Meteorological Institute of Belgium (RMI): experiences from Belgium
- Hidde Leijnse: Royal Netherlands Meteorological Institute (KNMI): experiences from The Netherlands
- Pierre TABARY, Meteo France: experiences from France
- Niels Einar, DHI Water & Environment, Denmark: marine X-band local area weather
- Søren Liedtke Thorndahl, Aalborg University, Denmark: experiences from Denmark with X-band radar
- David McLaughlin, Univ. of Massachusetts at Amherst, USA: CASA X-band radar project
- Herman Russchenberg, TU Delft: experiences with X-band radar in The Netherlands
- Cas Decloedt, KU Leuven, Belgium: first experiences with the Leuven X-band radar

- Li-Pen Wang & Susana Ochoa Rodriguez, Imperial College London: research on combining rain gauge and radar data using Kalman filter

Opening workshop

The workshop was opened by a welcome by Patrick Willems (KU Leuven) and a general overview presentation by Marie-Claire ten Veldhuis (TU Delft, RainGain coordinator) on the RainGain project. After a short presentation of the different participants, the aim, focus and practical organization of the workshop was explained by Patrick Willems.

Workshop Topic 1: X-band and C-band radar calibration: methods and experiences

Since the goal is to obtain fine scale (temporal and spatial) rainfall estimates, the question was raised by Niels Einar on what resolution is required for the project. One of the goals of the project is to set up an interfacing between the demands by the urban flood modelers and forecasters and the possibility to deliver this resolution by the radar meteorologists. It was agreed that the aim values for the spatial and temporal resolution are 5-10 minutes and up to 100m.

The precise location of the radar is also mentioned as an issue. The radar is mostly located in the study area, whereas it might be better to place it outside of the region of interest, because of the clutter in the direct surroundings of the radar.

To facilitate the conversations between radar meteorologists and urban hydrologists, some nomenclature is decided upon, namely:

- Radar calibration: the electrical calibration of the reflectivity of the radar
- Radar adjustment: the adjustments made to the radar reflectivity estimates to give good radar rainfall estimates

Laurent Delobbe mentioned that the radar of the RMI in Jabbeke (Belgium), which lies within proximity of the Leuven and London case, is now almost operational. This could be a valuable asset for both sites.

For the radars operated by the RMI, the electronic calibration is done by introducing the radar signal into a wave guide (known strength introduced in the radar wave guide) and by monitoring the point reflectivity of towers in the radar image (known reflectivity under normal conditions). This is updated regularly (once a month).

Hidde Leinsse (KNMI) mentioned that the resolution of an C-band radar is not necessarily coarser than the resolution of an X-band radar. The resolution does not depends on the wavelength but on the scanning strategy. Where the C-band radar is mostly used to cover a greater area than the X-band radar, the C band could also be used for fine resolution rainfall estimates in the proximity of the radar, if the scanning strategy is adapted for this application.

The KNMI uses different strategies to have a good electronic calibration. The noise on the radar measurements is monitored and used as an indicator of the quality of the measurements. The emitting power of the sun (known power) is also used as a source of calibration; this however only checks the reception chain. The methods of the RMI (fixed clutter points and introducing a known signal in the wave guide) are also used by the KNMI about once a week.

On an event basis, the KNMI also statistically compares the reflectivity in a given volume measured by different radars; this method is still to be implemented on a real time basis.

For dual polarization radar, there is the possibility to check the consistency between the polarimetric moments to monitor the radar performance.

The solar power is also used for electronic calibration in the Swiss Alps for X-band radars. There is however also the possibility to measure the solar power with an S-band radar and convert the power to the expected power at C-band. This can be used as a quality check of the C-band radar measurements.

The radar alignment (the direction in which the antenna is pointing) is also monitored, since small deviations on this alignment could give serious errors on the location of fine scale (up to street level) rainfall estimates.

The influence of the terrain on the ability to correctly measure the reflectivity is questioned. It is explained by the radar experts that there is no influence of the terrain on the electronic calibration of any of the radars considered within the scope of this project.

The UK MetOffice mostly uses the techniques described before, as well as a vertical scan (every 5 minutes) to calibrate the polarimetric variable Z_{Dr} by the droplet shape.

MeteoFrance uses several of the radar checks discussed before, such as a vertical scan for Z_{Dr}. They also check the offset of PHI_{Dp}, which gives an overall good check of the performance of the radar. The quality of all radar products improves if the calibration of the polarimetric moments is good, otherwise the quality might be lower. That is why MeteoFrance switches back to single polarization if some kind of errors occur or the calibration is found to have a significant offset.

The MeteoFrance radar team uses radar to radar comparison to check the performance and also radar-gauge comparison (on a monthly basis). The stability on the calibration is found to be around +/-1dB, which gives an offset of 15% in the rainfall estimates derived from the radar measurements. The Z_{Dr} parameter however has to be calibrated more carefully, since a stability of +/- 0.2dB is necessary to maintain the 15% offset in rainfall estimates. This is found to be not operationally maintainable, so MeteoFrance does not use the absolute value of Z_{Dr}.

DHI previously used a black box system to calibrate their X-band radar, based on a statistical relation between the measurements and the expected results. They now however feed an exact amount of reflectivity into the wave guide, which allows for a better calibration. Because of the moving speed of the rainfall and the small spatial resolution, the time averages are still a bit problematic.

It is mentioned that the use of disdrometers (or a network of disdrometers) could give an extra benefit to the radar estimates. There is however no operational network of disdrometers available.

For the RainGain partners, TU Delft (their operational X-band radar at the Cabauw site) now uses K_{DP} as a check of the reflectivity and the calibration in total. The dual polarization in combination with the Doppler measurements allow for a more accurate suppression of clutter, while keeping the rain signal.

For the Leuven case, the location was based on clutter tests.

For the radar in Paris, the manufacturer will include the software for the electronic calibration.

For the London case, the C-band radars of the MetOffice are already operational and will be upgraded for the RainGain project.

Tim Darlington stated that the order of magnitude for the attenuation at C band is about 1dB/km, he also mentioned that for X-band, this may even be an order of magnitude higher.

For the correction of the attenuation, the MetOffice uses the parameter PHI_{Dp}, which gives better results than the conventional methods for single polarization radars.

The possible influence of the vertical structure (such as the bright band phenomena, the drop off of the reflectivity with the height, etc) is not accounted for in this processing algorithm. The influence of the used Z-R relation is also not checked. This could influence the results.

The polarimetric variable KDp is not directly used in the attenuation correction due to malfunctioning of the software. New software is being developed at the moment.

The RMI uses radar composites from different radars when one is affected by attenuation. This technique is also used by the other meteorological offices. The comparison could also be between C- and S-band radars (used by MeteoFrance), since S-band radars are less prone to suffer from attenuation.

MeteoFrance also uses the parameter PHI_{Dp} for the attenuation correction, where the impact of the temperature and drop size distribution is accounted for.

Other techniques that were proposed by the participating radar experts are:

Remco Uijlenhoet (from Wageningen University) uses the Hitchveld-Borden algorithm for conventional radars. This is an attenuation correction method based on a reflectivity – specific attenuation relation. This algorithm is sensitive to numerical instabilities and its performance depends on the initial reflectivity. The method can also be applied on fixed clutter points for the total path integrated attenuation. This backward method is more stable but its performance depends on the reflectivity of the clutter point.

Hidde Leijnse (of the KNMI) mentions that this backward method can also correct for wet radome attenuation.

Pierre Tabari (from MeteoFrance) uses the reflectivity of the first gate as a proxy for the rainfall over the radar. 40dBZ of reflectivity above the radar causes an attenuation of 6dB.

Niels Einar Jensen (DHI) compares the total signal loss to the S-band radar signal and mentions that the wet radome attenuation could be limited by putting some sort of roof over the radome of the radar.

It is mentioned by the radar experts that if the received radar signal falls back to the noise level, the content is totally lost. This could possibly limit the range of the X-band radars for extreme events.

Workshop Topic 2: X-band versus C-band performance: experiences

Herman Husschenberg (of TU Delft) shows a comparison, for the same event, of X- and C-band radar observations. The comparison shows a more detailed image at X-band, but sometimes there are zones with signal extinction due to attenuation. The spatial resolution at X-band is 30 x 30m; at C-band 1 x 1km. From the comparison, it can be clearly shown that there is high variability within the 1 x 1km grid. The temporal resolution at X-band is 1 minute, at C-band 5 minutes.

As mentioned under topic 1, the resolution of the radar is not a function of the wavelength. The resolution is a function of the used pulse length and the beam width. For a C-band radar, this means that a specially dedicated scan could be used to scan the area close to the radar with a finer resolution.

MeteoFrance uses a downscaling method with advection fields to produce rainfall estimates with a temporal resolution of 1 minute (out of estimates with a 5 minute resolution).

The question is still where exactly the rain will fall. The rain measured within the 30m resolution grid cell may fall somewhere else because of wind effects.

The UK MetOffice will try to adapt their scanning schemes and radar properties to get a super resolution image with their C-band radars. This can be done by changing the beam width or the pulse length, as mentioned before. The pulse length must however not become too short, because the sensitivity is a function of the energy in the pulse. The temporal resolution could however give errors due to the copying of the rain clouds on several locations.

Hidde Leijnse from the KNMI gave some figures on the performance of different radar types. The X-band radar at IDRA (single polarization) gives an underestimation of 30-35% after attenuation correction. But also at C-band there is serious underestimation. However, after corrections (new calibration, clutter removal, wet radome attenuation and different Z-R relation) the C-band works rather well.

The influence of the atmospheric conditions is not investigated by the KNMI. Remko Uijlenhoet (Wageningen University) tried to correlate the Z-R relationship to the atmospheric conditions but found no significant correlations.

Pierre Tabary (from MeteoFrance) shows the benefits of X-band radar for rain rate estimations trough the use of K_{Dp}, (not at low levels). The polarimetric variable Z_{Dr} is not tested due to stability issues.

Chedo Maksimovic mentions that the radar signal should be accumulated before comparison with rain gauges and that for the gauges, it would be better to use a network of gauges to create a radar like signal.

It is mentioned that the rainfall statistics are usually still based on the rain gauge information.

David McLaughlin of the CASA project also gave a presentation about phase array radars.

Workshop Topic 3: Integration of X-band, C-band and rain gauge measurements: methods and experiences

Søren Thorndahl (Aarhus University) compared some results of the X-band LAWR (adapted marine radar) with the DHI's C-band radar for the Veijle municipality. The results of the X-band LAWR radar are not so accurate.

For the Leuven case, the LAWR-CR radar (also an X-band adapted marine radar), the results are better, possibly due to the different hardware in the two models.

Through the OPERA research project, network details on the operational weather radars will be placed online including information on the quality of the rainfall products. The ideal radar measurement processing chain will also be an outcome of the OPERA project.

The RMI compared a number of radar gauge merging techniques, including geostatistical methods, and have concluded that for their study, the kriging method (including external drift) preformed best. For the simple kriging method, the quality of the gauge data is critical.

The added value of the C-band is clear when the X-band radar signal suffers from extreme attenuation and the signal is completely lost. However, the C-band radar volume information is not always more reliable at the coarser scale.

Radar - gauge merging should always be the last step in the chain to achieve fine scale rainfall estimates. All the other correction mechanisms should be applied first.

The idea is proposed to generate minimal rainfall detection maps, being maps where the minimal observable rainfall intensity is shown. This gives an idea of the quality of the data before merging the different radar sources.

The KNMI applies a Mean Field Bias based on 3h accumulations before merging their 2 C-band radars. This gives good results. They also integrate other data sources by gauge comparison and bias correction to form a spatially corrected composite.

The use of microwave links (20-40GHz, mostly 3-4km length, used for cell phone communication) is suggested as an extra data source for rainfall estimation in urban areas.

For these microwave links, the attenuation could be used a proxy for the rainfall rate, since there is a linear relation between the attenuation and the rainfall rate. These links are close to the ground and mostly free of clutter. These can thus be used as an extra data source of rainfall estimation or creating attenuation maps for the X-band radar.

Rainfall estimates can be made based on Z or Z_{Dr} separately. It is however better to use the two combined, especially for low rainfall rates. For high rainfall rates, the use of K_{Dp} gives the best results.

There is always the possibility of stataistical/stochastic downscaling (both space and time resolution are adapted). These go down to 10m in spatial and 20 seconds in time resolution

Topic 4: Fine-scale rainfall estimation: recommendations and guidelines

Patrick Willems initiated the final discussion and concluded the workshop with an overview of the main items discussed during the workshop, which will form the main topics to be included in the "guidelines" on "fine-scale rainfall estimation" that will be prepared after the workshop, and the main findings/recommendations. The following outlined was proposed for the guidelines document:

- Electronic radar calibration (incl. electronic stability)
- Raw radar signal corrections:
    - Noise cutoff
    - Clutter removal
    - Attenuation correction
    - Volume / vertical profile correction (e.g. over/undershooting)
- Radar scanning strategy:
    - beam width/resolution
    - speed/frequency:
        - slower: more accurate
        - quicker: fast moving, changing convective storms better captured
    - pulse length
- Rainfall estimation:
    - Based on:
        - Reflectivity (Z)
        - Differential reflectivity (ZDR): better relationship with DSD
        - Differential phase (KDP): to estimate attenuation, strong KDP – R relationship when R is high
        - Drop size distribution (DSD)
    - Errors due to highly non-linear physics of radar detection of precipitation:
        - Electronic stability radar
        - Detection range, ground clutter, blockage
        - Anomaly echoes
    - Dependence on atmospheric conditions (rain regimes, wind, humidity, temperature, …)
    - Influence of radome
    - Use of disdrometer
    - But: more understanding needed on mechanism of cloud dynamics and microphysics, on interaction of hydrometeors and radar waves

- Differences in types of radar technology:
  - Dual pol versus simple-pol
  - Fine versus coarser resolution
    - X-band
    - C-band: high resolution possible (increase scan speed, sharpen beam)
    - But: what is preferred: increase resolution or increase accuracy same resolution?? (urban hydrology application driven)
- Ground truthing / adjustment:
  - First correction for different types of radar "errors" before adjustment based on rain gauges
  - Take rain gauge uncertainty into account (5-20% depending on type of precipitation)
  - Grid-scale versus point scale: comparison at point scale or grid scale / urban area scale? (e.g. kriging)
  - Downscaling / upscaling (spatial interpolation) needed
  - Static versus dynamic adjustment methods
  - Use of sewer observations?
- Fine-scale rainfall estimation:
  - Integration of all sources: C-band radar, X-band radar, rain gauges, even microwave links
  - Integration rainfall products requires quality of data to be considered (is time and space variable)
  - Several integration methods exist: mean field bias / Brandes correction / kriging (with external drift) / Kalman filter
  - Scale dependent variability needs to be considered
  - Stochastic downscaling methods (scaling laws, fractal theory)

It was agreed that KU Leuven would initiate the following two short-term actions:

- Preparation of a review document on methods and experiences in fine-scale rainfall estimation. It was agreed that the review document should not repeat material that is already available from other regional radar projects such as OPERA, but should focus on the use of fine-scale rainfall data for urban hydrological applications. The document aims to bridge the gap between the expertise fields of radar meteorology and urban hydrology/drainage/flood management and control. A draft outline for the review document will be sent by e-mail shortly after the workshop and participants and other radar experts (who expressed their interest in the workshop, but could not attend) will be asked for their suggestions. After KU Leuven (Laurens Cas Decloedt, Patrick Willems) prepared a

draft of the review document, it will be circulated for review and additional contributions under co-authorship of the document.

- The workshop presentations will be collected and send to the RainGain communication coordinator for uploading on the RainGain website. All presenters well be requested whether they agree with this for their presentation, or whether they prefer to remove some slides or apply any form of protection to the pdf.

The deadline for these two short-term actions was set at Friday 27 April 2012.

Radar visit

On 18 April in the morning (9:00 – 11:00) the participants to the workshop and the partners of the RainGain project had the chance to visit the Leuven radar (9:00 – 10:00) followed by a visit to the flood control center of the Flemish Environment Agency (VMM) at Leuven (10:00 – 11:00).

Attached

- Announcement and programme of the workshop
- List of participants + signatures

RAINGAIN International Workshop, Leuven, 16 April 2012

General aim of the workshop

Discuss among the scientific project partners and international experts methods and experiences, and prepare guidelines for radar calibration and fine-scale rainfall estimation

Programme

(chair: P.Willems)

9:00 – 9:30 Arrival and coffee
9:30 – 10:00 Welcome and introduction

10:00 – 11:30 X-band and C-band radar calibration : methods and experiences

11:30 – 12:00 Break

12:00 – 13:00 X-band versus C-band performance : experiences

13:00 – 14:00 Lunch

14:00 – 15:30 Integration of X-band, C-band and rain gauge measurements : methods and experiences

15:30 – 16:00 Break

16:00 – 17:00 Fine-scale rainfall estimation : recommendations and guidelines

19:00 – 21:30 Dinner

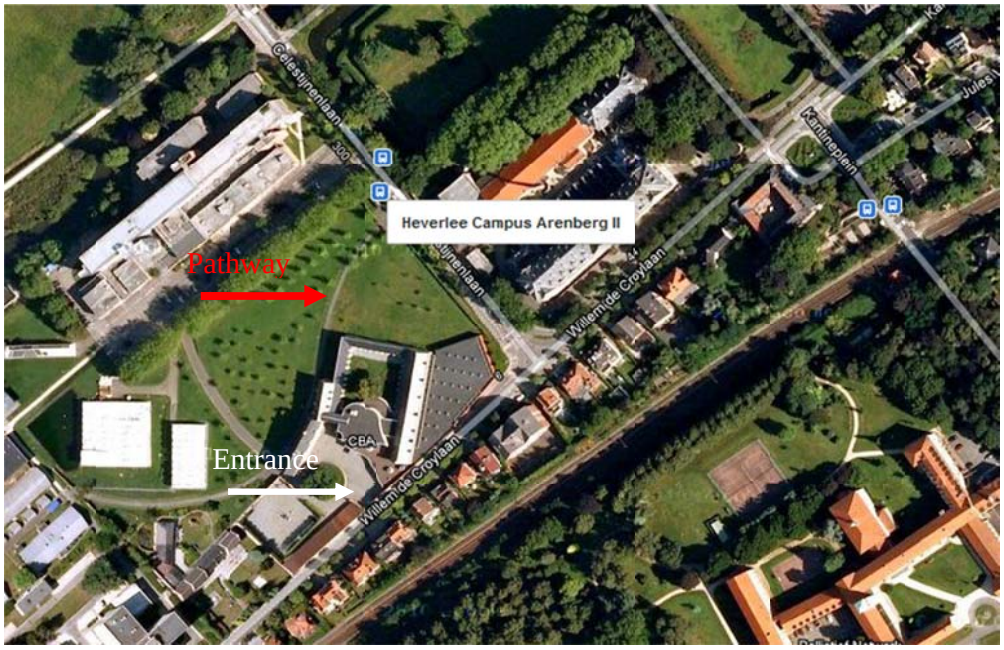
Contributions will be prepared by :

- Laurent Delobbe & Maarten Reyniers, KMI: experiences from Belgium
- Hidde Leijnse, KNMI: experiences from The Netherlands
- Pierre Tabary, Meteo France: experiences from France
- Timothy Darlington, UK Met Office : super-resolution C-band data UK
- Søren Liedtke Thorndahl, Aalborg University: experiences from Denmark with X-band
- David McLaughlin, Univ. of Massachusetts at Amherst, USA: CASA X-band radar project
- Cas Decloedt, KU Leuven: first experiences with the Leuven X-band radar
- Other scientific project partners
- Niels Einar, DHI
- Siao Sun, INSA lyon

RAINGAIN International Workshop, Leuven, 16 April 2012

Location

Arenberg Library Room: CBA 01.10 NICOLAS DE LE VILLEZAAL
(Address: CBA Celestijnenklooster, Willem de Croylaan 6, 3001 HEVERLEE)



Directions:

The Campuslibrary Arenberg (CBA) in Heverlee, 5 km outside Leuven, is situated on the corner of the streets "Celestijnenlaan" and "W. de Croylaan".

By bus: The library is accessible by bus. Approximately each 10 minutes a bus (bus 2 “Heverlee Campus”) leaves the station of Louvain to the campus. Get off at the stop ‘Heverlee Campus Arenberg II’. Then follow the small pathway to the entrance or follow the Celestijnenlaan and turn left to the W. de Croylaan. Along the W. de Croylaan there is the main entrance (white arrow).

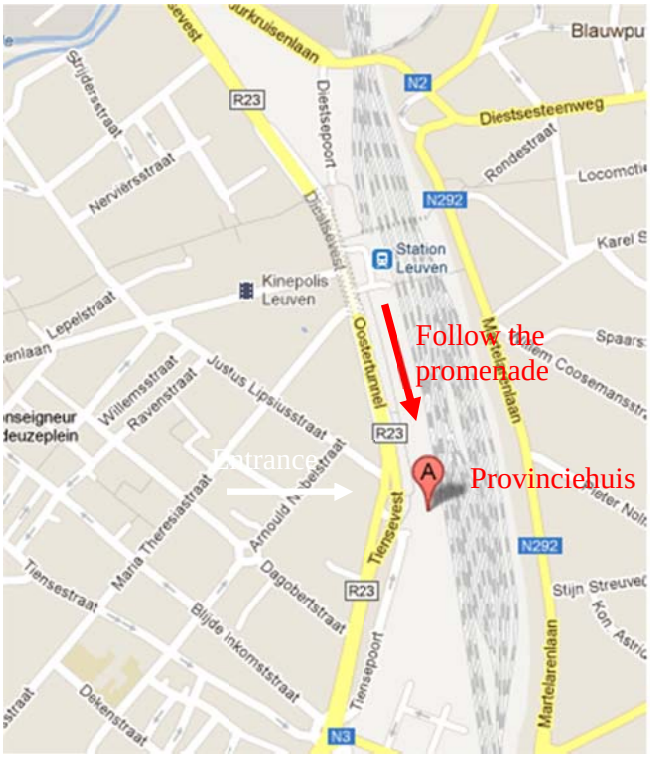
By car: To arrive at the library by car, follow the Celestijnenlaan and turn into the parking place next to the buildings of the department "Werktuigkunde". At the end of this parking place you will see on your left-hand side a route sign with ‘Campusbibliotheek Arenberg’. Just follow this sign to the parking.

By taxi: Ask the driver for the address: Willem de Croylaan 6, 3001 Heverlee.

RAINGAIN Radar visit (Optional), Leuven, 18 April 2012

Location

Provinciehuis building: we meet at the entrance at 9:30
(Address: Provinciehuis Vlaams-Brabant, Provincieplein 1, 3010 Leuven)



Directions:

The Provinciehuis building is located on walking distance from the railway station of Leuven. Just follow the promenade (marked with a red arrow) and you'll see the Provinciehuis building on your left hand side (see photo above).

By car: For your GPS, use the street name 'Tiensevest' to arrive at the Provinciehuis building. You can also use the parking 'De Bond', which is located near to the station. Just follow the signs to the parking.

INTERREG IVB

RAINGAIN International Workshop, Leuven, 16 April 2012

First Name	Name	Function	Company	Country	Signature
Ioulia	Tchiguirinskaia		ENPC	FR	
Auguste	Gires		ENPC	FR	
Johan	Van Assel		Aquafin	BE	
Čedo	MARSIVANIN		Imperial College	UK	
Morten	Borup		DTU/Krüger	DK	
Søren	Thrandahl		AAU	DK	
TIMOTHY	DARLINGTON		UK met office	UK	
Laurent	Delobbe		KMI	BE	
Diego	Mora		KUL	BE	
Herman	Russchenberg		TUD	NL	
Niels	Jensen		DHI	DK	
Marie-Claire	ten Veldhuis		TU Delft	NL	
Gino	Sum		INSA de Lyon	France	

INTERREG IVB

RAINGAIN International Workshop, Leuven, 16 April 2012

First Name	Name	Function	Company	Country	Signature
GUENDALINA	BRUNI	PhD	TUDELFT	NL	
Hjalte	Sørup	PhD	DTU	DK	
Remko	Uijlenhoet	Prof.	WU	NL	
Aart	Overeem	postdoc	WU	NL	
Alma	Schellart	Lechver	University of Bradford	UK	
Niels	Van Steenbergen	PhD	KUL	BE	
Li-Pen	Wang	PhD student	ICL	UK	
Maarten	REYNIERS	Scientist	KMI	BE	
DAVID	McLAUGHLIN	Prof	UMASS	USA	
Patrick	Willems	Prof	KULeuven	Belgium	
Laurens Cas	Deckodt	PhD researcher	KU Leuven	Belgium	

INTERREG IVB

RAINGAIN International Workshop, Leuven, 16 April 2012

First Name	Name	Function	Company	Country	Signature
Hidde	Leijnse	Researchar	KNMI	Netherlands	
Roland	Löwe	PhD	DTU	Denmark	
BARRY	O'BRIEN	Administrator	Logic	UK	
Stefan	Kroll	SU R&D	AQF	B	
LUIS	PINEDA	PhD	KULEUVEN	EC	
Susana	Ochoa	PhD	Imperial College	UK	
Nargna	Lukach	Researcher	KMI	Belgium	
EDOUARD	GOUDENHOOFDT	Researcher	RMI	BELGIUM	
PIERRE	TABARY	Head of weather Radar R&D	Météo France	France	