Status and plans of using ground-based GNSS at RMI

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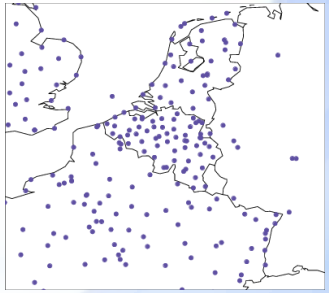
But: every GNSS-related activity at RMI is in close collaboration with Eric Pottiaux (ROB)!

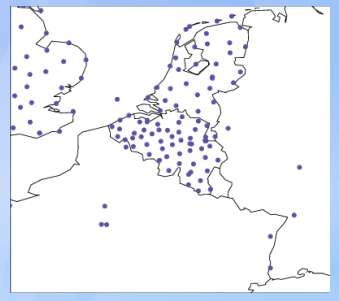
Outline

1. GNSS data assimilation at RMI
2. IWV intercomparison activities
3. GNSS and climate research
   i. IWV time series analysis
   ii. GNSS & climate models
4. Conclusions

1. GNSS data assimilation

- **NWP: current operational set-up in Belgium**
  - ALARO-0 cy38t1 with 3MT (Modular Multiscale Microphysics and Transport)
  - 4km horizontal resolution, 46 model levels, 180s timestep
- **Goal**: improve initialization of moisture variables in our LAM in order to obtain better precipitation and cloud forecasts, especially for severe weather events
- **Method:** Data assimilation of Zenith Tropospheric Delay (ZTD). The Royal Observatory of Belgium (ROB) provides hourly updated ZTD estimations, within the framework of E-GVAP:
  - Left: stations which provide standard hourly RINEX files
  - Right: stations which provide real-time observations

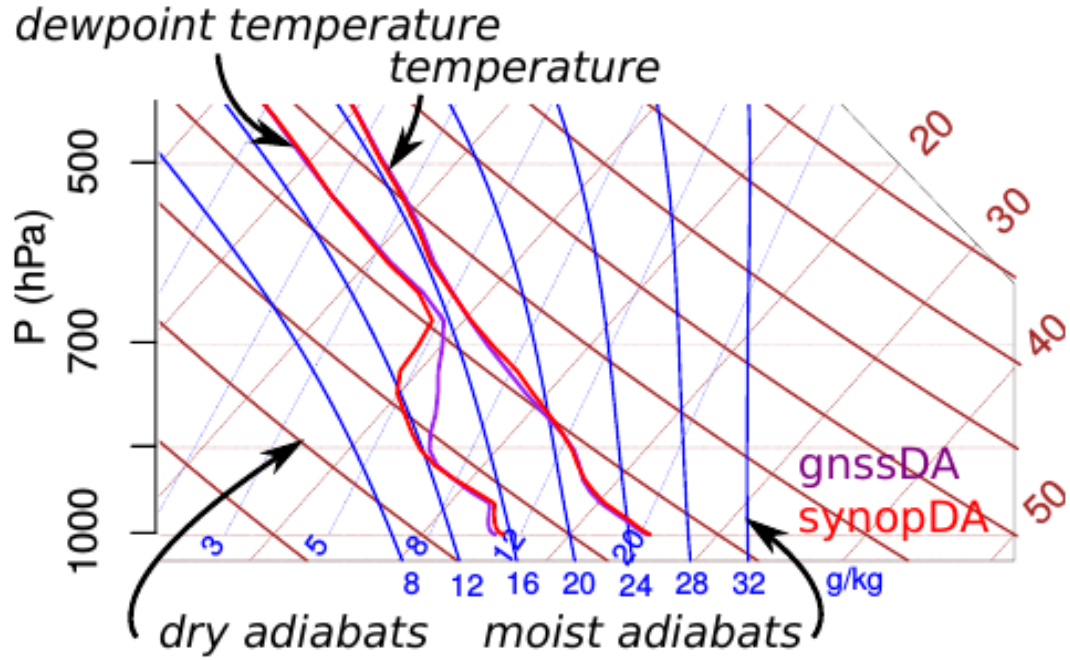


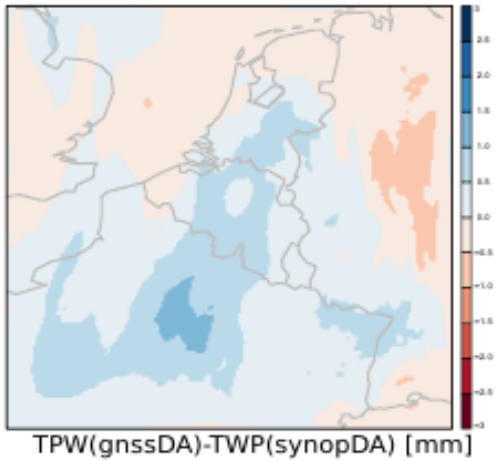


- Pre-processing and corrections:
  - Static bias correction => whitelist with bias and error statistics
  - Spatial thinning at 10 km., temporal thinning 6h (update cycle ⇒ 00, 06, 12, 18)
  - Hydrostatic correction for the station altitude
  - Constant error: atmosphere above the highest model level (1 hPa): absorbed in bias

1. GNSS data assimilation: case study

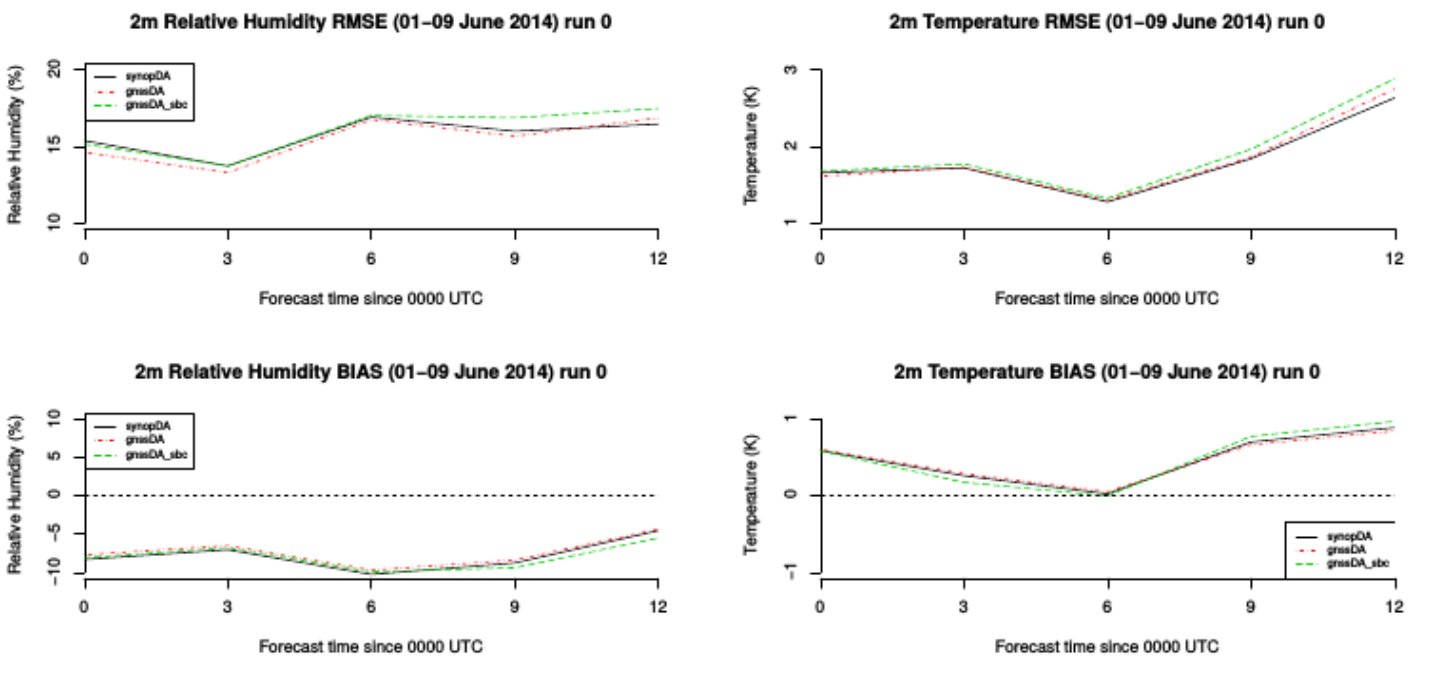
- **Pentecost storm (June 7-8-9 2014)** Over 500 M in damage claims in Belgium.
- **Impact** of ZTD assimilation on pseudo-soundings and total precipitable water (TPW):





1. GNSS data assimilation: case study

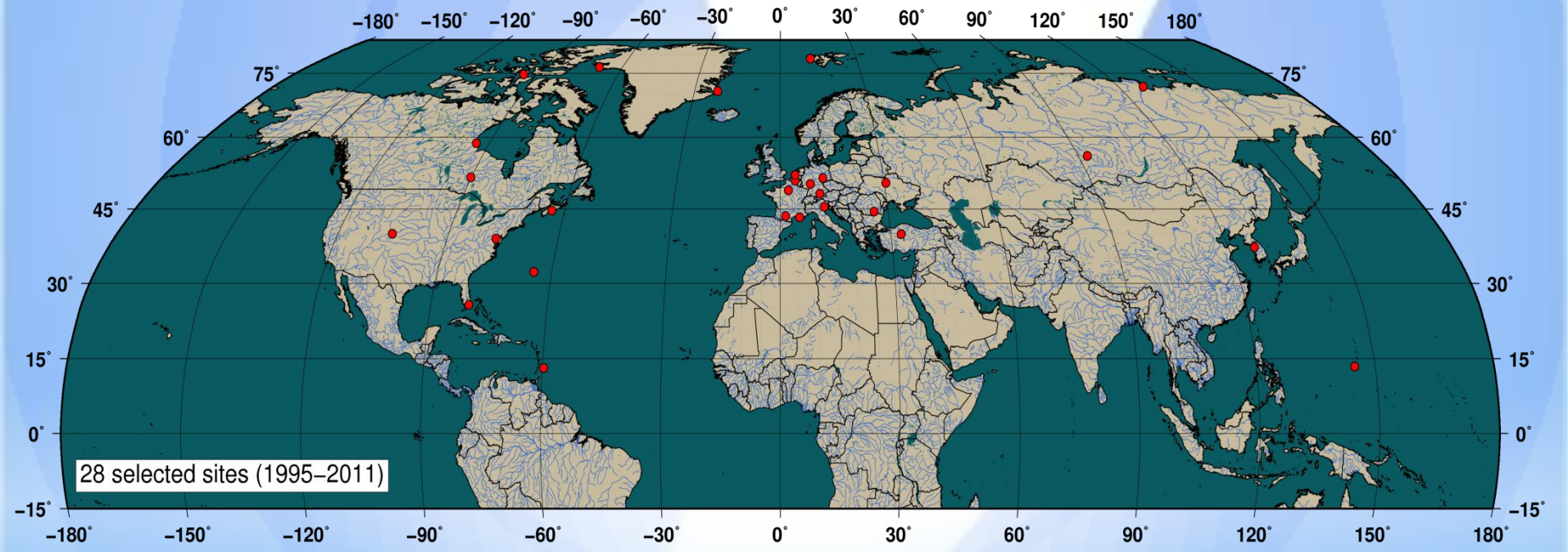
- **Scores:** RMSE (top) and Bias (bottom) of RH2m (left) and T2m (right)



- Assimilation of SYNOP data + non-bias corrected ZTDs (gnssDA): slightly **improved** RMSE and bias of the 2m relative humidity for short (under 9h) forecast range compared to SYNOP data only (synopDA).
- However, static bias correction (gnssDA sbc) largely cancels the positive effect of ZTD assimilation on RH2m: overestimation of the ZTD observation errors wrt background?

2. IWV intercomparison activities (PAST)

Van Malderen, R., Brenot, H., Pottiaux, E., Beirle, S., Hermans, C., De Mazière, M., Wagner, T., De Backer, H., and Bruyninx, C.: A multi-site intercomparison of integrated water vapour observations for climate change analysis, Atmos. Meas. Tech., 7, 2487-2512, doi:10.5194/amt-7-2487-2014, 2014.

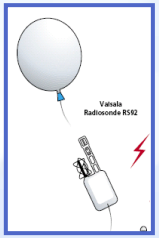


- IWV techniques intercomparison at 28 sites world-wide (NH)

IGS

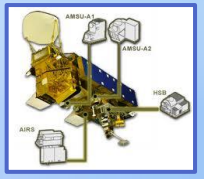
CIMEL

radiosondes



GOMESCIA

AIRS



2. IWV intercomparison activities (FUTURE)

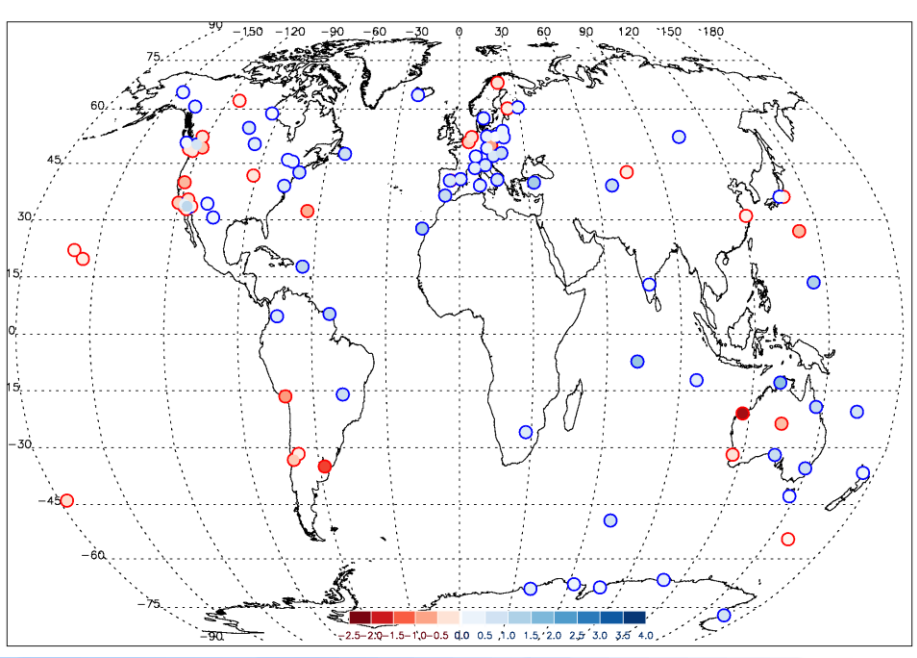
IWV techniques intercomparison

- between GNSS and radiosondes (Vaisala RS92), potentially also VLBI
- for the time period 2012-2015
- at GRUAN sites
  - Lindenberg (ldbg0, ldbg2)
  - [Potsdam (pots, potm)]
  - Ny Alesund (nya1, nya2)
  - Sodankyla (soda)
  - Lauder (ldb0,ldb2)

➔ topic of an internship for the period June-August 2016, but trainee resigned

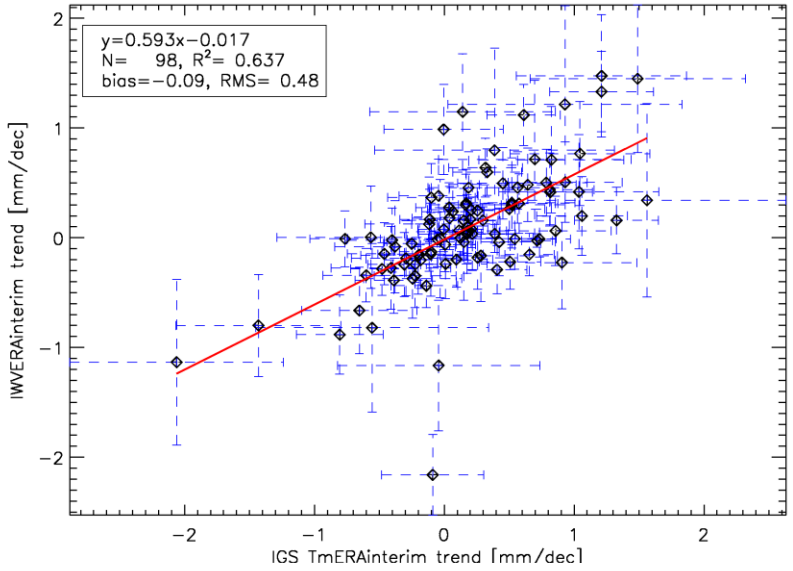
3. GNSS & climate research

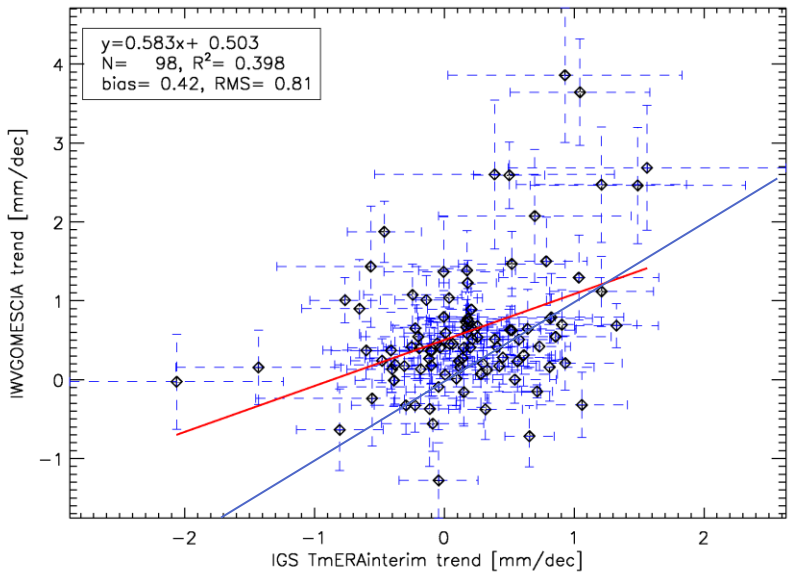
i. IWV time series analysis



IGS repro 1 + ERAinterim

- sensitivity analysis of meteo data on IWV trends
- interpretation of IWV trends and trend differences
- homogeneity of the time series!





3. GNSS & climate research

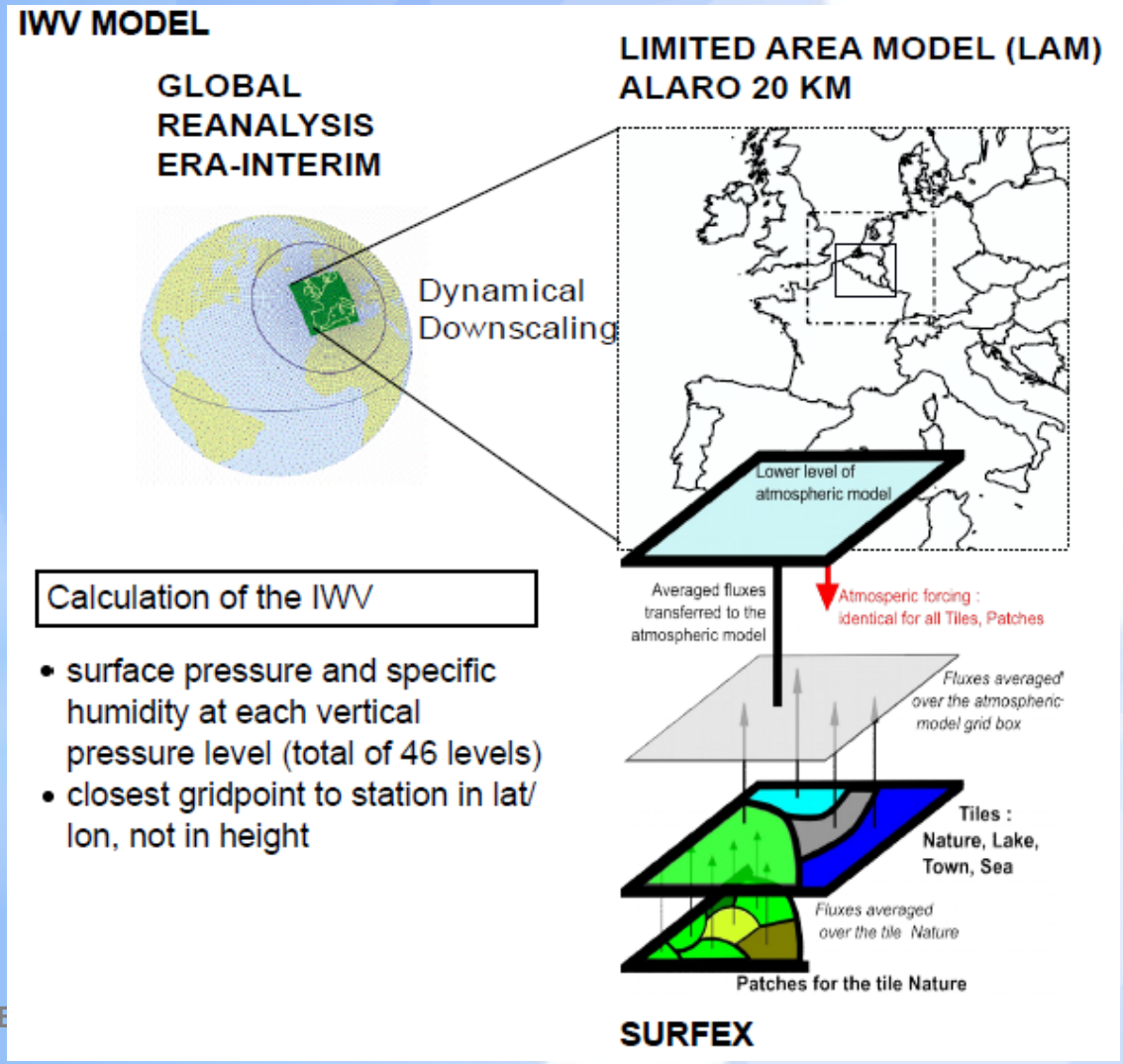
i. IWV time series analysis: homogenization

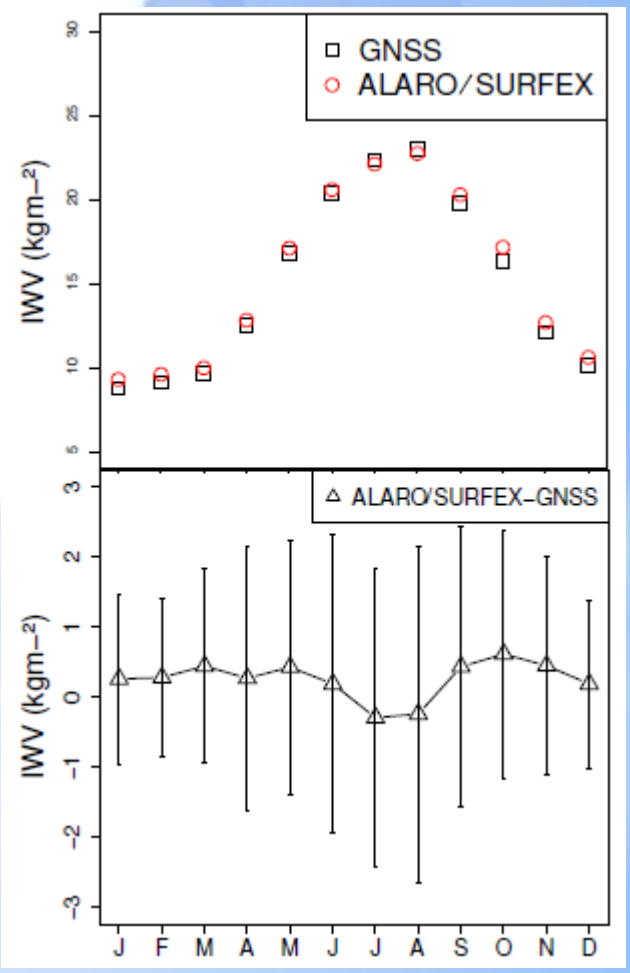
- sub-WG activity in GNSS4SWEC on homogenization of GNSS IWV time series
- 2 dedicated workshops: 26-27 April 2016 @ Brussels & 23-25 Jan 2017 @ Warsaw
- first focus on IGS repro 1
- Status
  - 6 different groups applied their homogenization tools on reference IGS repro 1, taken ERAinterim IWV as reference dataset
  - generation of synthetic datasets (for IGS repro 1, for IGS repro 1 - ERAinterim differences) with known offsets and different stochastic behaviour to test tools against truth
  - goal: homogenized reference IGS repro 1, to be used by community for climate studies.
  - future: homogenization of EPN repro 2 + IAG JWG 4.3.3 “GNSS tropospheric products for Climate” (chaired by R. Pacione & E. Pottiaux)

3. GNSS & climate research

ii. GNSS & climate models

- validation of regional climate models with GNSS IWV retrievals

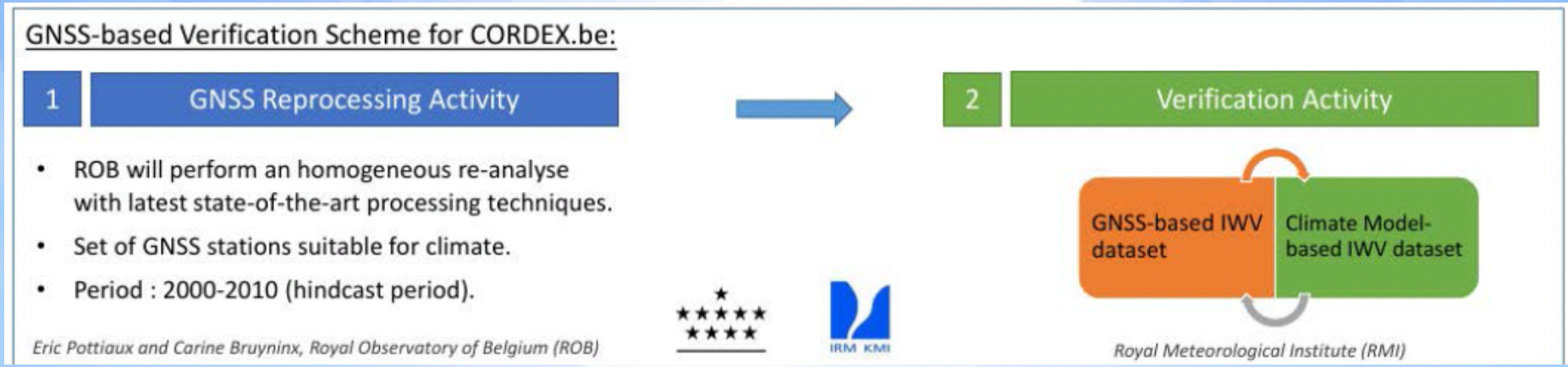




3. GNSS & climate research

ii. GNSS & climate models: CORDEX.be

- RMI is PI of the CORDEX.be project ("Combining Regional climate Downscaling Expertise in Belgium")
- provides a frame to combine existing, ongoing efforts in the Belgian climate community, to optimally bring CORDEX scale information to the Belgian local scales in a coherent way: *a stakeholder should get the same information from any of the 9 partners*
- GNSS data is used for the validation of the climate model based IWV dataset (details: talk by E. Pottiaux)



3. GNSS & climate research

ii. GNSS & climate models: SCIENCE4CS

- RMI is a member of the consortium SCIENCE4CS for the ERA4CS call ("European Research Area for Climate Services")

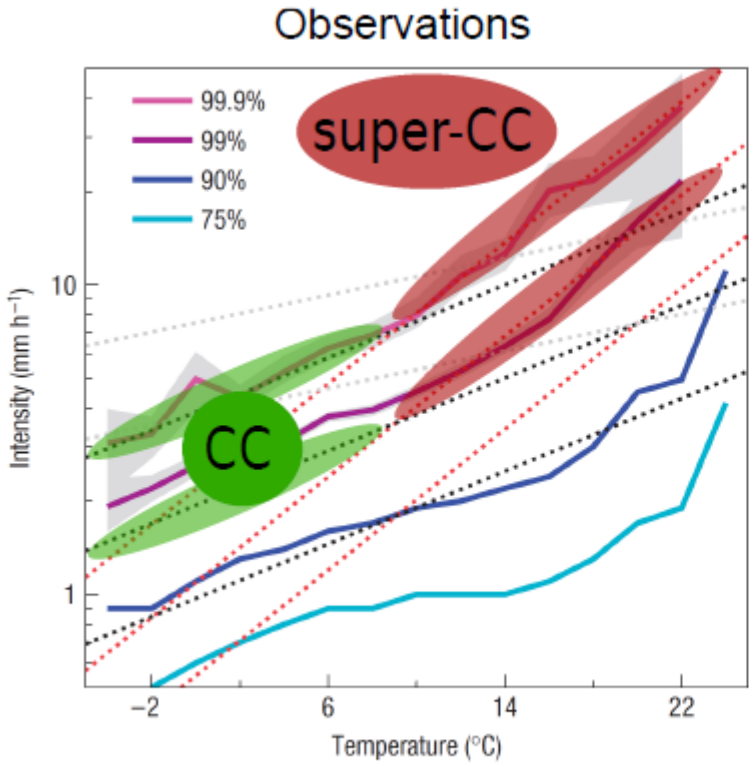
- SCIENCE4CS will provide decision-relevant kilometer-scale climate information through a new generation of comprehensive climate models and innovative analyses:
  1. SCIENCE4CS will employ convection-resolving Regional Climate Models (RCMs), Empirical Statistical Downscaling (ESD)methods and combined approaches in powerful new ways.
  2. these models will be evaluated via newly designed experiments over regions with high quality observational data of very high spatial resolution
  3. a practical, solutions-oriented and user-friendly interface will be developed which will go well beyond data provision to also include relevant sectorial guidance, best practices and data processing functionality

- **GNSS input (in collaboration with IGN):** new data sets of homogeneously reprocessed ground-based observations of Zenith Total Delays (ZTD) and Integrated Water Vapour (IWV) over Europe obtained from GNSS networks at high spatial resolution
  ➔ processing, screening, homogenizing, and applying quality control tests to the GNSS data, and creating gridded ZTD/IWV products and IWV trends and variability indices adapted to the evaluation of RCM simulations.

3. GNSS & climate research

ii. GNSS & climate models

- assess intense precipitation extremes under climate change



Lenderink & Van Meijgaard, Nature Geoscience 2008

- Same observed with models.
- Super-CC scaling not understood so far!!
- Different hypothesis:
  - Convection vs. stratiform rain
  - Statistical "transitional" artifact
- Statistical analysis of hypotheses superficial and not uniform

CC = Clausius Clapeyron
= saturated water vapour pressure changes 7% per 1°C warming

3. GNSS & climate research

ii. GNSS & climate models

- assess intense precipitation extremes under climate change
- role of GNSS:
  - use the Belgian dense network for a statistical validation (distribution-wise & one-to-one comparison) of the IWV fields of different climate models (and different resolutions/parameterizations)
  - study CC for IWV vs. temperature

4. Conclusions

- RMI is especially a user of GNSS ground-based data.
- The focus of our institute is especially on the climate applications of GNSS data (validation of climate models, homogenization of time series for long-term variability studies, etc.).
- RMI is well aware of the added value of GNSS data assimilation, but resources are lacking to take the necessary steps to make this operational.
- The use of GNSS data for nowcasting (INCA.be, Integrated Nowcasting through Comprehensive Analysis) is absent at RMI.