MEMO^2: MEthane goes MObile – MEasurements and MOdelling

Two MEMO^2 schools organised

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1. Executive summary

The MEMO^2 training program follows a holistic approach including disciplinary / interdisciplinary elements, individual / collective training, and theoretical / practical courses, all aiming to prepare the ESRs with key competences to tackle scientifically complex and societally relevant issues.

Targeted competences in MEMO^2 are the ability to: I) effectively and interactively use and develop tools such as innovative technologies, knowledge, and languages in an interdisciplinary way, II) act autonomously within the "big picture" of climate sciences, III) function and interact synergistically within a socially heterogeneous group, and IV) responsibly conduct and manage a challenging research project within 3 years. In MEMO^2, we will teach each ESR an ensemble of different knowledge, expertise, and life skills, both at individual and collective levels and the obligatory secondments tackle a wide variety of those skills. Within this context two MEMO^2 schools were organised for the ESRs. Each school included theoretical and practical training (learning-by-doing approach), including active participation of all participants.

The first school ("Getting ready for MEMO^2") was mainly organised by the partner organisation ECN and the UU as coordinator, shortly after the recruitment had been completed in February 2018. The school was associated to the first joint measurement campaign and aimed to equip the ESRs with all necessary theoretical and contextual information as well as practical tools to ensure that all ESRs successfully start their research projects at a comparable theoretical and practical basic level.

The second school ("Methane and society") was organized by UVSQ, in February 2019, and associated to the Midterm Review Meeting. The school focussed on the societal implications and the policy and economy-relevant aspects of the research program, and involved several non-academic partners of MEMO^2 contributing through lectures and workshops. The program had an interactive role play character, i.e. the ESRs worked in groups to figure parties to the United Nations Framework Convention on Climate Change (UNFCCC) and represent dedicated countries or groups of countries. They used the World Climate Simulation of ClimateInteractive (https://croadsworldclimate.climateinteractive.org), and discussed and negotiated in the interest of their countries.

This report is a compilation of the milestone report MS2 about the 1st school and intensive campaign (submitted 14 March 2018) and the blog about the 2nd school (published 5 March 2019, https://h2020-memo2.eu/2019/03/05/memo2-school-imagine-the-difficult-and-the-impossible/).

2. Getting MEMO² started – 1st School

2.1 General overview

Within MEMO² several measurement and intercomparison campaigns are planned to obtain joint data. The first intensive campaign was associated to the 1st MEMO² school. Both events were closely connected and will be reported together.

The school and the campaign, held from 5 to 16 February in Schoorl, The Netherlands (see circle, Fig. 1), were organized by Arjan Hensen and his team from the partner organization ECN, supported by Utrecht University (UU) and the University of Groningen (RUG). All beneficiaries of MEMO² and the partner organization Shell, Picarro, TNO, and OonKay were involved in the preparation and scientific program of the school, e.g. by giving lectures during the school or accompanying the field work and supporting data analyses at the end of the campaign.

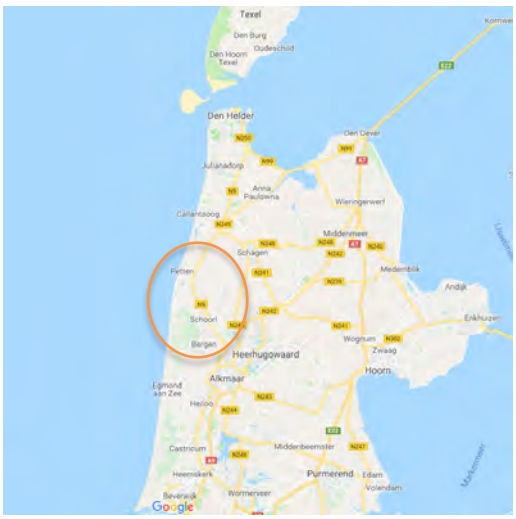


Fig. 1: Schoorl and Petten, location of the 1st MEMO² school / campaign in the northern part of the Netherlands

This was the first MEMO² network event after finishing the recruitment, and all ESRs presented their individual projects by posters to the group.

The group of recruited ESRs has differing educational backgrounds and can be roughly divided into a modelling and a measuring group. During the project a close collaboration is expected from the ESRs, which requests a basic understanding of both, fieldwork and modelling.

So, the first part of the activity aimed on imparting basic scientific knowledge of the project (MEMO² school), including campaign planning and modelling. The second part aimed on the intercomparison of instruments of the measurement groups and introducing all students to fieldwork and data analysis methods (MEMO² campaign), based on a learning-by-doing approach.

In total 8 teams from ECN, UU, AGH, UVSQ, LU, RHUL, UHEI, and RUG brought their measurement instruments and gathered data during the joint fieldwork. During the first week the ESRs followed theoretical lectures while the instruments ran together to obtain data for an intercomparison of instruments. After the theoretical part, the ESRs were introduced to the instruments and started first joint sampling along a dedicated transect. Also a joint tracer release experiment (CH_4, N_2O, C_2H_2) and a drone flight with AirCore sampling were conducted.

All teams sampled together along several distinct routes with different sources, including farms, biogas plants, gas installations, or landfills. Besides the joint activities, the ESRs got the opportunity to choose transects for measurements that are interesting for their individual projects. For isotopic analysis discrete bag samples were taken by RHUL, UU, and UHEI, to be analysed later in the home labs.

During the last days of the campaign the data were shared and the ESRs learned how to compile their data sets, how to analyse and evaluate data. They discussed data quality and required metadata. Based on the data from the campaign the ESRs operated and compared different models such as different Gaussian plume models, a 3-D CFD model, and a Lagrangian dispersion models (GRAL-GRAMM).

Due to the amount and complexity of the gathered data the data analyses will continue beyond the campaign. Selected results will be shown at the 1st Annual Meeting and included in the 1st Annual Progress Report.

The event was awarded 6 ECTS, and each ESR got a certificate of participation.

2.2 Participants

The MEMO² school and the associated campaign were an obligatory network event for all ESRs.

Besides them, participants from all beneficiaries of MEMO² and the partner organization Shell, Picarro, TNO, and OonKay were involved (Fig. 2). They either gave lectures during the theoretical part of the school or accompanied the ESRs during the measurement campaign. In total 38 participants took part in the 1st MEMO² school.

Fig. 2: ESRs and some of the PIs during the school

Table 1: participants of the 1st MEMO² school / campaign

Participant	Last name	First name	Affiliation
1	Bakkaloglu*	Semra	RHUL
2	Bartyzel	Jakub	AGH
3	Bousquet	Philippe	UVSQ
4	Brunner	Dominik	EMPA
5	Chen	Huilin	RUG
6	Defratyka*	Sara	UVSQ
7	Denier v. Gon	Hugo	TNO
8	Eckhardt	Henrik	UHEI
9	Emmenegger	Lukas	EMPA
10	Fernandez*	Julianne	RHUL
11	Fisher	Rebecca	RHUL
12	Hensen	Arjan	ECN
13	Hirst	Bill	SHELL
14	Hofmann	Magdalena	PICARRO
15	Holst	Jutta	LU
16	Korben*	Piotr	UHEI
17	Krol	Maarten	WU
18	Lakomiec*	Patryk	LU
19	Lanoisellé	Mathias	RHUL
20	Lowry	Dave	RHUL
21	Maazallahi*	Hossein	UU
22	Menout*	Malika	UU
23	Morales*	Randulph	EMPA
24	Necki	Jaroslaw	AGH
25	Nisbet	Euan	RHUL
26	Oonk	Hans	OONKAY
27	Raznjevic*	Anja	WU
28	Rinne	Janne	LU
29	Röckmann	Thomas	UU
30	Schmidt	Martina	UHEI
31	Stanicki*	Badrudin	EMPA
32	Stanisavljevi*	Mila	AGH
33	Szenasi*	Barbara	UVSQ
34	v.Heerwaarden	Chiel	WU
35	Vinkovic*	Katarina	RUG
36	Walter	Sylvia	UU
37	Winkler	Renato	PICARRO
38	Yver-Kwok	Camille	UVSQ

* MEMO² ESRs

2.3 Preparation

Both the school and the campaign were part of the proposal. The school was initially planned to be held in France, but it was decided during the Kickoff Meeting that it would be more beneficial for the ESRs to combine the 1st MEMO² school with the 1st intensive measurement campaign in the Netherlands, ensuring a closely related theoretical and practical introduction. The preparation started 10 months in advance and was continuously developed during regular tele-conferences within the consortium.

As ECN organised the practical part of the event and offered their lab facilities for the campaign, the area around Petten, NL, was chosen as sampling location (Fig. 1). Thus, the lectures and data evaluation were planned close by, at the Slothotel Igesz in Schagen (www.igesz.nl). Due to bankruptcy, the hotel was closed with immediate effect one week before the school started, so the location changed short-term to the Jan van Scorel Hotel in Schoorl (www.hoteljanvanscorel.nl).

2.4 Agenda 1st MEMO² school

During the project a close collaboration is expected from the ESRs, which requests a basic understanding of both, fieldwork and modelling. The MEMO² school was scheduled for two weeks, divided in a theoretical part in the first week and a practical part in the second. As the group of recruited ESRs has different educational

backgrounds, the first part of the activity aimed on imparting basic scientific knowledge relevant to the project. The school included general and specific scientific courses as well as lectures about complementary skills, a poster session, and informal discussion rounds to stimulate communication and networking (Table 2).

The second part aimed on the intercomparison of instruments of the measurement groups and introducing all students to fieldwork and data analyses (MEMO² campaign). During the first week available instruments were already running at ECN for intercomparison.

Table 2: Agenda of the 1st MEMO² school / campaign

	Mon., 5 Feb.	Tues., 6 Feb.	Wed., 7 Feb.	Thurs., 8 Feb.	Fri., 9 Feb.	Sat., 10 Feb.	Sun., 11 Feb.	Mon. 12 Feb.	Tues., 13 Feb.	Wed., 14 Feb.	Thurs., 15 Feb.	Fri., 16 Feb.
8.30 - 9.30		Atmospheric methane budget – Euan Nisbet	Atmospheric physics – Maarten Krol	Methane measurement techniques – Lukas Emmenegger	campaign	campaign	Day off Suggestions visit Texel Amsterdam musea Free day	campaign	Data evaluation	Data evaluation	Data evaluation	Presentation of results
9.30 - 10.30		Greenhouse effect and societal relevance – Euan Nisbet	Atmospheric chemistry – Thomas Röckmann									
10.30 - 11.00		coffee break	coffee break	coffee break								
11.00 - 12.00		Global biogeochemical cycles – Janne Rinne	Atmospheric methane modeling – Philippe Bousquet	Isotopes in atmospheric sciences – Dave Lowry								
12.00 - 13.00			Dispersion modeling – Chiel van Heerwaarden									Evaluation
13.00 - 14.00		lunch	lunch	lunch						lunch	lunch	lunch
14.00 - 15.00	poster presentation	Experimental design and sampling strategies – Bill Hirst	Metrology, statistics and uncertainties – Jarek Necki	Picarro training – Renato Winckler	3D modeling – Chiel van Heerwaarden				Data evaluation (using tracer method) – Camille Yver-Kwok	Data evaluation	Presentation of results	
15.00 - 16.00	poster presentation		Methane Inventories – Jarek Necki		Activity units for getting emission factors – Hugo Denier v.d. Gon, Hans Oonk							
16.00 - 16.30	poster presentation	coffee break	coffee break	coffee break	coffee break				coffee break	coffee break	coffee break	
16.30 - 17.30	poster presentation	Intellectual property rights – Bill Hirst	Application of mass-balance models to the global methane cycle – Maarten Krol	Harmonisation of measurement methods – Martina Schmidt	career planning, CDP discussion Time management, teaching skills – Philippe Bousquet				How to work with B2SHARE – Jutta Holst	Arduino platform - Jakub Bartyzel	Arduino platform - Jakub Bartyzel	
17.30 - 18.30												
18.30 - 20.00												
20.00 informal panel discussions			Ethics in science and good scientific practice, Research integrity and scientific misconduct - Maarten Krol, Philippe Bousquet	Gender issues in scientific collaboration – Martina Schmidt, Lukas Emmenegger								

2.5 1st Intensive MEMO² campaign

The measurement campaign took place in the area of Petten and around Alkmaar. All teams performed mobile measurements together along several distinct routes with different sources, some examples are given in Fig. 3. The transects were chosen based on the type and size of sources such as farms, biogas plants, peak gas installation, or landfills. For several sources it was possible to sample at different distances.

Besides the joint activities, the students got the opportunity to choose transects for measurements interesting for their individual projects. For isotopic analysis discrete bag samples were taken by RHUL, UU, and UHEI, to be analysed later in the home labs. Preliminary results were presented by the students during the last two half day sessions of the school. Further elaborated results will be presented at the 1st Annual Meeting and in individual progress reports of the ESR projects in the 1st Annual Progress Report.

Two MEMO² schools organised

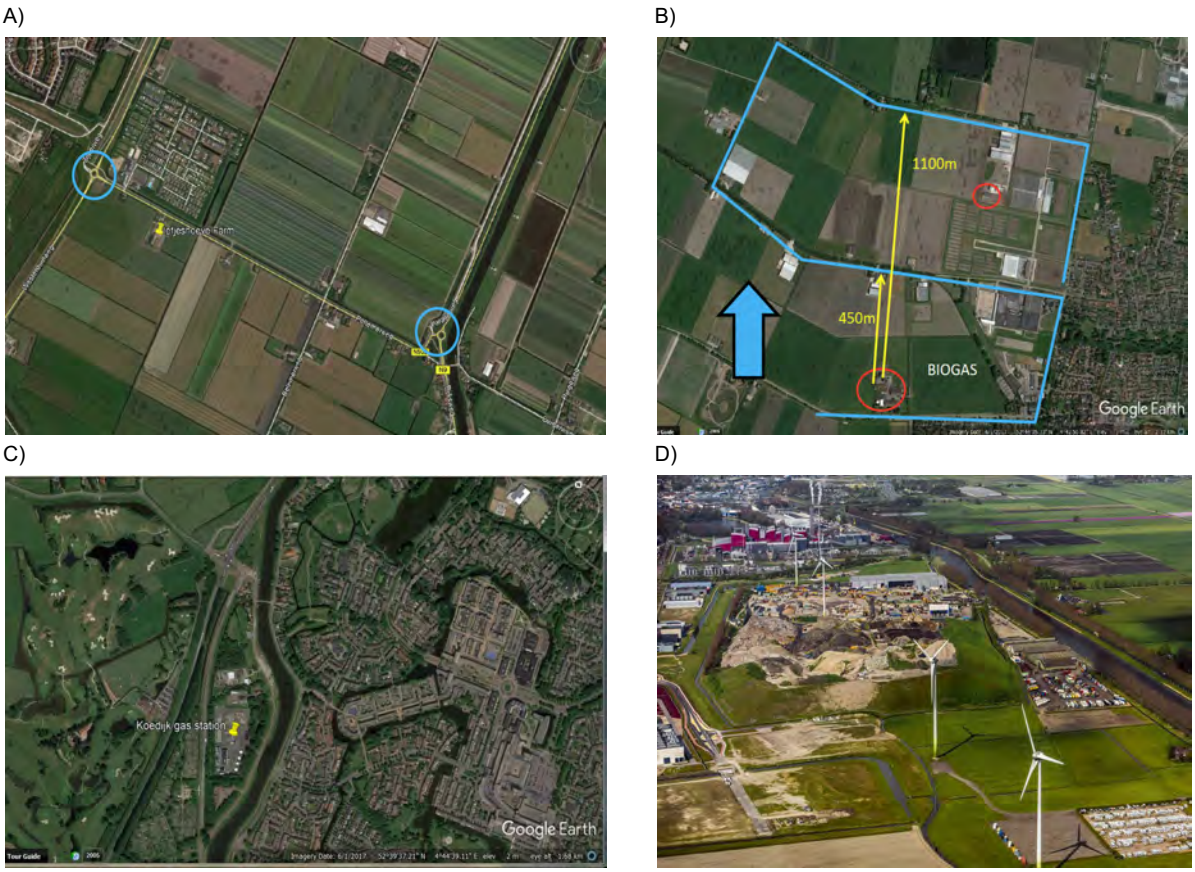


Fig. 3: Sampling transects – A) Lefjeshoeve - transect along a farm with cowhouse; B) Biogas - transect along a biogas plant and a farm; C) Gas station north of Alkmaar; D) Landfill south of Alkmaar

Most teams used Picarro analysers to measure methane, but also instruments from Los Gatos and Aerodyne. Besides methane, carbon dioxide (CO_2), carbon monoxide (CO), nitrous oxide (N_2O), water vapor (H_2O), ethene (C_2H_6) and acetylene (C_2H_2) were measured, as well as meteorological parameters necessary for data analyses.

Table 3: overview of used instrumentation and measured species during the campaign

Partner	Mobile platform	Instrumentation	Measurement species
RUG	Drone DJI Inspire I	UAV AirCore & Picarro	CH_4, CO_2, CO, H_2O
UHEI	Van VW	Picarro G2201i	CH_4, CO_2, $^{13}CH_4$
LSCE	Van	Picarro G2201i and G2203	CH_4, CO_2, $^{13}CH_4$, $^{13}CO_2$, C_2H_2
RHUL	Car 4WD	Picarro G2301, LGR UMEA and bag sampling	CH_4, CO_2, C_2H_6/CH_4 ratios + $^{13}CH_4$ in lab
AGH	Car 4WD	Picarro G2201i, 2D wind, T,P,H, PM10, PM2.5	CH_4, CO_2, $^{13}CH_4$
ECN	Van	Aerodyne QCL & Ecophysics NOx & Lasx PM	CH_4, C_2H_6, CO_2, N_2O, CO, (NH_3), NO, NO_2, PM1-10
EMPA	Drone, not yet available	Homebuilt CH4 QCLAS	CH_4, H_2O
LU	aircraft not available	Picarro 13CH4 available	CH_4, $^{13}CH_4$
UU	Van	Picarro CO2 & CH4 and Picarro backpack. LGR	CH_4, CO_2
Other field equipment			
ECN	Meteo 1	wind profile 5 heights Gill 2 D, Vaiasla all weather station	ws,wd,rh,t,p,rain, H, u*
ECN	Meteo 2	sonic Gill - WMPro	ws,wd,H, u*
ECN	Trailer (mobile lab)	vaisala all weather station and space for instruments	ws,wd,rh,t,p,rain
UU	Meteo		

2.6 Evaluation

The ESRs were provided with templates to evaluate the individual lectures and also the whole school, including the practical campaign part and miscellaneous items such as accommodation, catering and networking. The feedback was anonymous.

Fig. 4 shows the mean evaluation of the lectures and lecturers (18 lectures in total), ranking from 1 (not satisfying) to 4 (good). The overall mean ranking was 3.7 ± 0.8. The evaluation of the whole event is given in Fig. 5. The ESRs evaluated separately the school in general, the theoretical and practical part, and the miscellaneous activities such as accommodation, catering and networking. The overall evaluation mean (green dot) is 3.2 ± 0.8.

For both, the evaluation of the lectures / lecturers and the evaluation of the whole event, the standard deviations reflect the different levels of the ESRs. As the group of recruited ESRs has differing educational backgrounds and can be roughly divided into a modelling and a measuring group, lectures were partly experienced as too low or too high level. Several ESRs gave individual comments, which will taken into account for the organisation of future events. The overall results and the individual comments clearly show, that the event in general was highly appreciated by the ESRs and experienced as interesting and useful for there projects and personal development.

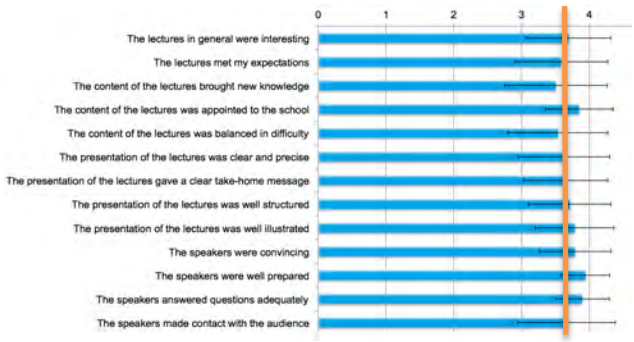


Fig. 4: ESR evaluation of in total 18 lectures. The orange line gives the overall mean ranking (3.7 out of 4) of the lectures and lecturers.

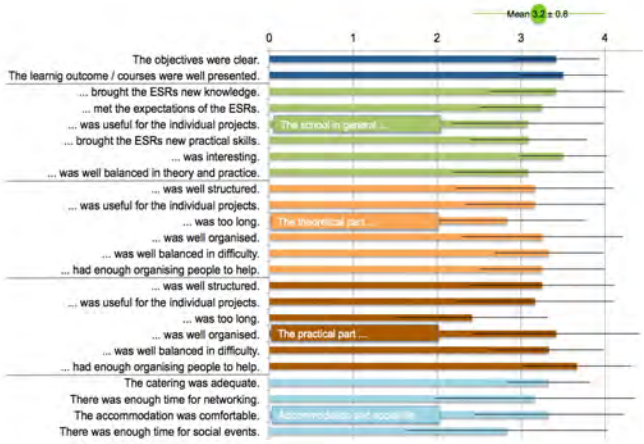
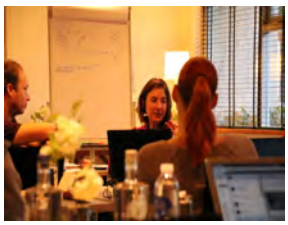


Fig. 5: Evaluation of the school in total. The overall evaluation mean (green dot) is 3.2 ± 0.8.

2.7 Some impressions

Poster session and lectures



Two MEMO² schools organised

Preparation for mobile CH_4 measurements

Set up of the tracer release experiment and miscellaneous meteorological equipment

Drone flight with AireCore sampling

Fig. 6: impressions of the 1st MEMO² school 2018

2.8 History of the 1st School

Table 4: Organisation history of the 1st MEMO² school

Version	Author(s)	Date	Changes
1		23-24 March 2017	Started discussion changing country for the school and combining school and campaign
		April - June 2017	Decision to go to Schagen, NL, as final location and start local organisation
		June – December 2017	Finalizing the core agenda and local organisation of the school, start campaign organisation
		December – February 2017 / 2018	Finalizing campaign preparation
		February 2018	Last organisational fine tuning, short-term change of location to Schoorl, NL
		5 – 16 February 2018	1st MEMO² school / intensive campaign held
		March 2018	Report submitted to EU

3. Methane and society – 2nd School

3.1 General overview

The 2nd MEMO² school about "Methane and society" school was organized by UVSQ and the UU in St. Quentin en Yvelines, France, associated to the Midterm Meeting (18 – 22 February 2019). It aimed at investigating links between methane and society through different aspects: climate change, economy, policy, social sciences, media and mitigation. For each session of the school, the participants had to conduct personal or group work after introductory lectures. All along the school, ESRs represented a country or a group of countries (among: USA, EU, China, India, other developed countries, other developing countries) in the different sessions whenever relevant.

One of the exercises for the ESRs was a role play in which they had to figure parties to the United Nations Framework Convention on Climate Change (UNFCCC) and to negotiate the best for their country. A challenge, which the ESRs faced by using the interactive World Climate Simulation of ClimateInteractive (https://croadsworldclimate.climateinteractive.org).

Beside the role play, the ESRs learned about e.g. how to build GHG emission scenarios based on economic indicators, participate to a decision-making process and negotiate in their interest, conduct a simplified perception analysis, or propose a mitigation plan for an assigned country or region.

They were also introduced to the use of scientific data in a societal context and the communication of them to different stakeholders.

3.2 Participants

All ESRs participated in the school. Most of the MEMO² PIs were not involved in lecturing during the school, but the ESRS had the opportunity to further discuss with the consortium and some of the lecturers afterwards during the associated Midterm Meeting.

Table 5: overview of participants of the 2nd MEMO² school and/or the Midterm Meeting

Participant	Last name	First name	Affiliation
1	Bakkaloglu*	Semra	RHUL
2	Bousquet**	Philippe	UVSQ
3	Broquet	Gregoire	UVSQ
4	Brunner	Dominik	EMPA
5	Chen	Huilin	RUG
6	Defratyka*	Sara	UVSQ
7	Denier v. Gon	Hugo	TNO
8	Fernandez*	Julianne	RHUL
9	Heimann	Martin	MPI
10	Hirst**	Bill	SHELL
11	Hofmann	Magdalena	PICARRO
12	Holst	Jutta	LU
13	Korben*	Piotr	UHEI
14	Krol	Maarten	WU
15	Lakomiec*	Patryk	LU
16	Lowry	Dave	RHUL
17	Maazallahi*	Hossein	UU
18	Massiot**	Aude	Libération
19	Menout*	Malika	UU
20	Morales*	Randulph	EMPA
21	Necki	Jaroslaw	AGH
22	Oonk**	Hans	OONKAY
23	Pison	Isabelle	UVSQ
24	Racque**	Elise	Télérama
25	Ravelid*	Jonas	EMPA
26	Raznjevic*	Anja	WU
27	Röckmann	Thomas	UU
28	Sapart**	Celia	FRS-FNRS
29	Sarno	Alessandro	Afval Sverige
30	Schembri**	Patrick	UVSQ
31	Schmidt	Martina	UHEI
32	Stanisavljevi*	Mila	AGH
33	Sweeney	Colm	NOAA
34	Szenasi*	Barbara	UVSQ
35	van Heerwaarden	Chiel	WU
36	Vanderlinden**	Jean-Paul	UVSQ
37	Velzeboer	Ilona	ECN/TNO
38	Vinkovic*	Katarina	RUG
39	Walter	Sylvia	UU
40	Winkler	Renato	PICARRO
41	Wolkowicz	Wojciech	PGI
42	Yver-Kwok	Camille	UVSQ
43	Zavala-Araiza**	Daniel	EDF

* MEMO² ESRs / ** MEMO² lecturers

3.3 Preparation

The school was mainly organized by UVSQ, with support from the UU. The overall idea and schedule of the school was already part of the proposal, and the more detailed preparation started in June 2018. It was continuously further developed, and the consortium was kept up-to-date during the regular tele-conferences.

In December 2018 the ESRs were informed about the agenda. To enhance the commitment the ESRs were asked to dedicate themselves to a specific country or group of countries during the school, so that they will investigate aspects of climate change through the eyes of „their" country and represent it in the UNFCCC role play (Table 6). ESRs were expected to have a basic knowledge about the situation of their dedicated country and have read the Paris Agreement.

Table 6: Geographical country groups and their ESR representatives

Country	ESRs
Europe	Randulph Morales Julianne Fernandez
USA	Anja Raznjevic Katarina Vinkovic
Africa	Barbara Szénási Hossein Maazallahi Jonas Ravelid
India	Sara Defratyka Semra Bakkaloglu
China	Malika MEnaud Mila Stanislavljevic
Russia	Patryk Łakomiec Piotr Korbeń

One week before the school, the ESRs got individual information about their countries to be prepared during the negotiations, and some material / links about the topic in general, e.g. https://files.lsce.ipsl.fr/public.php?service=files&t=a7318c18917d9d51f6bf1f20c40db93c (incl. the Paris Agreement or UNFCCC Analysis Intended Nationally Determined Contributions (INDCs)) or related movies such as "Cowspiracy" from Kip Andersen and Keegan Kuhn (http://www.cowspiracy.com).

3.4 Agenda of the 2nd MEMO² school

The 2nd MEMO² Network school was organised in the context of "Methane and the society". During the 1st school, students were introduced to the theoretical and practical part of measurements and modelling. In the second school, the societal aspects of climate change were addressed. The idea was to concept the school approaching economic, social and environmental issues as interdependent aspects of climate change. The school had 6 different topics and was a mix between general introductions to the topics and practical parts, e.g. the impact on society, which data are needed and interesting for policies, by whom might our data be used or how to use them in the context of climate change mitigation.

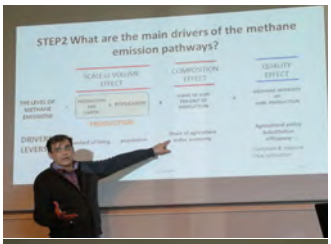
To cover these topics, 6 blocks were set-up, each of approximately 3 hours and including a theoretical introduction and an interactive practical part. Together the ESRs discussed e.g. how their country will develop, which mitigation / adaption strategies they will take, and their ideas to implement the Paris Agreement.

Table 7: Agenda of the 2nd MEMO² school

	Morning 9:30 – 13.00	Afternoon 14.00 – 17.30	Evening
18/02/2019	**Session 1: Climate change / World Climate Simulation** Philippe Bousquet (UVSQ)	**Session 2: Climate change and economics** Patrick Schembri (UVSQ)	**Discussion** **Dinner on your own**
19/02/2019	**Session 3: Societal aspects** Jean-Paul Vanderlinden (UVSQ)	**Session 4: Dealing with media** Elise Racque (Télérama), Celia Sapart (FRS-FNRS), Aude Massiot (Libération)	**Joint Aperitive & Dinner discussion**
20/02/2019	**Session 5: Mitigation** Hans Oonk (OonKay), Bill Hirst (Shell)	**Session 6: Policy** Daniel Zavala-Araiza (EDF)	**Free** (possible visit of le Louvre)

3.5 Sessions and activities

Fig. 7: Prof. Bousquet as chair of the Climate Simulation, Bi-lateral discussion and propositions to negotiate country contributions to limit global warming



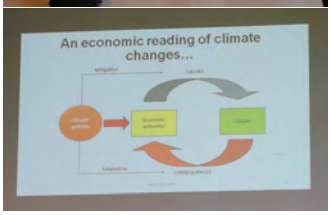


Fig. 8: Prof. Schembri (UVSQ) introducing the drivers of emission pathways and the economic reading of climate change on the example of methane

3.5.1 Climate change / World Climate Simulation: Philippe Bousquet (UVSQ)

The first day was an interactive start of the 2nd MEMO² school, dedicated to societal challenges around climate change in general and methane in particular. Prof. Ramstein (UVSQ) gave a first introduction to the topic, on methane all along the climate history.

Than Philippe Bousquet from UVSQ took the role of the convention president, and the ESRs represented a country or region. They discussed and negotiated their national contributions to mitigate climate change and by this help reducing the global greenhouse gas emissions, first on national level, then in bi-lateral and finally in plenary discussions. They made a 1st restitution of propositions, and after some more group work to revise their propositions and continuing negotiations with the other "countries", they presented their final propositions to limit global warming to 2°C. Unfortunate for the climate, they ended up at an unfavourable temperature reduction of only 2.7 °C. By this interactive role play the ESRs got an idea how to argue when defending the interests of their country by keeping the global need to reduce the emissions of greenhouse gases in mind. And they realized how difficult such negotiations are.

3.5.2 Climate change and economics: Patrick Schembri (UVSQ)

Beside scientific aspects, the economic aspects are an essential part during negotiations. Which costs can we expect, depending on different future scenarios, and who will take them? Which parameters do we have to consider when calculating "the" costs?

The ESRs got a first overview of the economic reading of climate change and its drivers, given by Prof. Patrick Schembri from the UVSQ. He presented the various forms of interdependencies between economic activities and climate change, with a focus on methane emissions. Based on the main drivers, the ESRs developed socioeconomic scenarios for their countries by quantifying the players and defining economic growth rates over the next decades. They used the ECOMET model to treat the methane scenarios, a simplified economic growth model whose structure is disaggregated at a sectoral level through the Kaya's identity approach, with a focus on both the energy and agriculture sectors. They learned in detail about the different economic needs and potentials of their countries, which have to be considered when negotiating their contributions. They had to anticipate the future evolution of certain indicators and quantify them so as to simulate the corresponding trajectories of methane emissions. They also had to propose policies to reduce these emissions by specifying the levers on which these mitigation strategies could be based. The ESRs worked on related papers about the future trends of both the energy and agriculture sectors and on the World bank database for the historical data, and finally presented the economic strategies of their countries with respect to their contributions to the Paris Agreement.

3.5.3 Societal aspects of climate change: Jean-Paul Vanderlinden (UVSQ)

Another question was about perceptions people have or might have on climate change. What would it take for people to perceive methane emissions as something that matters? Prof. Jean-Paul Vanderlinden from UVSQ introduced the ESRs to the fact, that also social aspect clearly matters, and that scientists in the climate debate should not only consider "scientific" knowledge, but also "social" knowledge and collective influences, cultural backgrounds, individual experiences, values and interests. Aim was to develop a better understanding of the kind of interface that science and society may need in order for knowledge to guide action. The ESRs learned that just "learning" the scientific facts is not enough and that the triangle of normative, pertinence and evidence claims needs to be considered. After the theoretical introduction the ESRs searched the verbal expressions of these claims in different press clippings, to get a feeling of how to situate scientific knowledge within the world of perception.

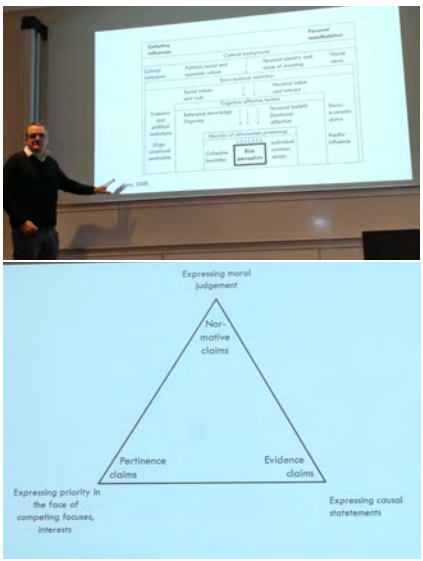


Fig. 8: Prof. VanderLinden (UVSQ) demonstrating that just learning the scientific facts is not enough in the climate debate to convince a sceptic audience

3.5.4 Dealing with media: Elise Racque (Télérama), Celia Sapart (FRS-FNRS), Aude Massiot (Libération)

Scientists in the field of climate change often have to deal with doubting and sceptical people, people which are ignoring the scientific common knowledge, and people who have absolutely no clue about the subject. During this session the ESRs were introduced to the basics of oral and written communication strategies. They also learned how journalists work and how to "deliver" their results to the media. Dr. Sapart from the FRS-FNRS in Brussels showed the ESRs together with her collegues, Aude Massiot from the French daily newspaper Libération, and Élise Racque from the French weekly magazine Télérama, that scientists and journalists think, work and communicate in different ways – generalists versus specialists. They showed how to deal with these differences, how to understand and anticipate it, how to organize and structure scientific presentations to ensure an effective communication with respect to different audiences. In a practical part the ESRs had the opportunity to simulate a short radio interview with the two journalists and to get feedback on blogs they have written about their projects.

Fig. 9: Dr. Sapart and her collegues Elise Racque and Aude Massiot (Télérama and Liberation) demonstrating the need for a clear audience orientated and adjusted communication strategy

3.5.5 Mitigation: Bill Hirst (Shell) / Hans Oonk (OonKay)

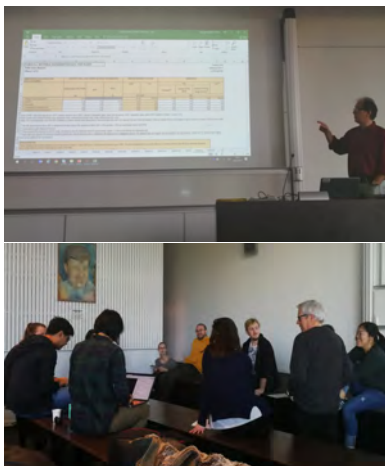


Fig. 10: Dr. Hirst and Dr. Oonk introducing how to develop a mitigation stratey

The third day started with an overview of obligations countries have committed to by signing the Paris Agreement. Dr. Oonk from OonKAY briefed the ESRs on current understanding of estimated methane emissions per activity such as agriculture, waste handling, oil and gas production and use. Dr. Hirst from Shell took over, provided an overview of the case for measuring actual mass emission rates from sources and summarised the variety of survey methods available to map mass emission rates from sources or defined areas. Based on the briefing, the ESRs were asked to devise a mitigation plan for their assigned country and to present their strategy. The goal was to demonstrate a credible route to delivering a substantial methane mitigation for their region, judged by the relevant Paris Agreement goals and timescales.

They had to explain their reasoning behind the plan and how their plan reflects the constraints and information provided. To get them in the right spirit, Bill invited them to a very convincing thumb-wrestling exercise, showing that collaboration is much more productive than competition!

3.5.6 Climate change and policy: Daniel Zavala-Araiza (EDF)

The closing lecture, dedicated to policy and policy-relevant emission data, was given by Dr. Zavala-Araiza from the Environmental Defense Fund (EDF). Scientists are not only driven by the pay-off by good scientific results, it is also the idea that those results can change the world or at least might have the potential for it. Next to the communication with the broad public and the media, it is also crucial that results are communicated with policy makers. Thus, in the last activity the ESRs were faced with recent real-world case studies where quick response of researchers was needed in a way usable for policy makers, which differs from communication to e.g. other scientists. The activity highlighted the role of policy-relevant measurement data and the necessary process to communicate results to a diversity of stakeholders.

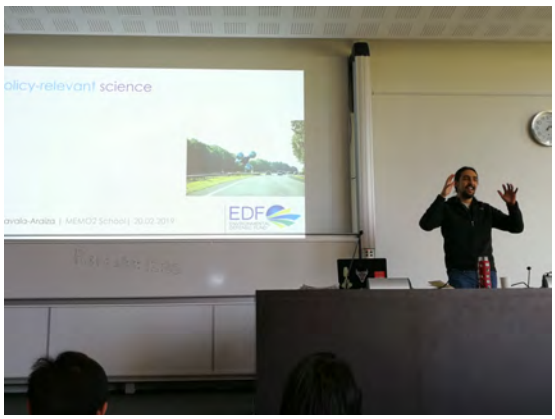


Fig. 11: Dr. Dr. Zavala-Araiza from the Environmental Defense Fund (EDF) presenting recent case studies, on which the ESRs had to respond quickly and relevant for policy makers

3.6 Evaluation

Similar to the 1st school, the ESRs were provided with templates to evaluate the individual lectures and also the whole school, including the practical part and miscellaneous items such as accommodation, catering and networking. All 13 ESRs gave feedback, which was anonymous.

Fig. 12 shows the evaluation of the 2nd school, ranking from 1 (not satisfying) to 4 (good). The overall mean ranking was 3.7 ± 0.6.

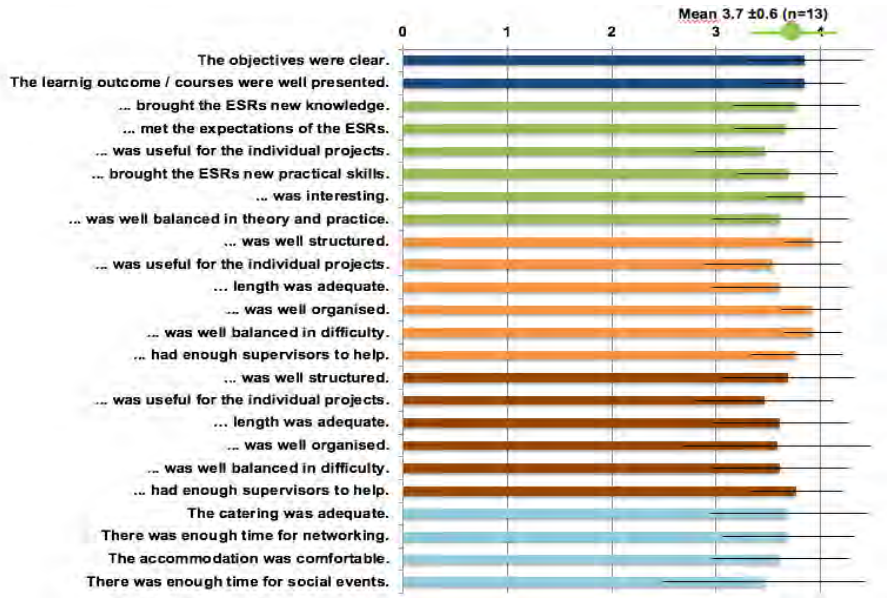


Fig. 12: Evaluation of the 2nd MEMO² school by the ESRs

Several ESRs gave individual comments, also in the feedback to the 1st school. These comments were considered, when planning the 2nd school and will also be considered for the organisation of future events.

The overall results and the individual comments clearly show, that the event and particularly the practical part was highly appreciated by the ESRs and experienced as interesting and useful for their projects and personal development.

3.7 History of the 2nd School

Table 8: Organisation history of the 2nd MEMO² school

Version	Author(s)	Date	Changes
1		June 2018	Started initial planning based on Grant Agreement, location of school adjusted to scheduled Midterm Meeting in Groningen, NL, regular skype meetings started until the school, using Google docs / sheets for preparation
		July 2018	Informing the PIs about the school and start searching for lecturers within the consortium
		October 2018	Consortium informed that the location had been changed to France as initially planned for the 1st school, no concerns about the location change
		December 2018	Finalizing the core agenda and local organisation of the school, informing consortium incl. hotel suggestions (own booking)
		January 2019	General reminder, last organisational fine tuning and final planning, checking attendance / catering
		February 2019	Preparation material sent to ESRs, school held
		March 2019	Evaluation from ESRs shared within organising and lecturer team, upload blog on website

3.8 References and useful literature

Intended Nationally Determined Contributions (INDCs), 2015, https://unfccc.int/process-and-meetings/the-paris-agreement/nationally-determined-contributions-ndcs

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