Report on the 8th IAMC Annual Meeting

Potsdam Institute for Climate Impact Research (PIK)
November 2015

Summary of the Meeting

The 8th meeting of the Integrated Assessment Modelling Consortium (IAMC) was organized and hosted by the Potsdam Institute for Climate Impact Research in November 2015. Around 140 representatives from the IAM and collaborating communities joined more than 80 oral and poster presentations and shared views on the state of the art and future prospects in integrated assessment modelling.

Participants discussed the relevance of IAMs in informing policy with a focus on the IAM contribution to the Paris negotiations, and their role in evaluating the Paris outcomes, especially the intended nationally determined contributions (INDCs). Moreover, main IAM community achievements were presented, including the Shared Socio-economic Pathways (SSPs), which will be published in 2016. At the heart of the conference, scientists presented progress on four focus areas, namely the analysis of climate change impacts, different approaches to handle uncertainty of IAM projections, the linkage between climate policy and broader sustainable development objectives as well as potentials and risks of climate engineering and carbon dioxide removal technologies. A specific session was dedicated to the presentation of posters on recent IAM work in 11 thematic areas (Annex III). Participants concluded that there is scope for further development and improvements, including work on model evaluation to strengthen and maintain confidence in IAMs. However, all participants also recognized the importance of IAMs in their unequalled capability to develop long-term transformation strategies needed to address climate change.
The meeting agenda, the list of participants and poster titles are provided in the Annexes at the end of this document. Presentations and posters are available for download at the IAMC website: http://www.globalchange.umd.edu/iamc/events/eighth-annual-meeting-of-the-iamc-2015-2/

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DAY 1: MONDAY, NOVEMBER 16, 2015

OPENING PLENARY

Welcome and introductory remarks
In his welcome talk, **Ottmar Edenhofer (PIK)** briefly presented the structure of the Potsdam Institute for Climate Impact Research, its research domains, as well as its main model projects, PIAM and POEM. He highlighted PIKs contribution to the integrated assessment of transformation pathways, its research on institutional designs and distributional impacts. Based on his experience as Co-Chair of the Working Group III of the Intergovernmental Panel on Climate Change (IPCC), he gave insights on the IPCC work on the AR5 and drew some conclusions for the AR6, such as the importance of integrating climate impacts, adaptation and mitigation analysis as well as creating the link to the Sustainable Development Goals (SDGs).

Introduction to the meeting
John Weyant (U Stanford & EMF) briefly introduced the IAMC and highlighted its main achievements, including the development of the Representative Concentration Pathways

(RCPs) and the close to final work on Shared Socio-economic Pathways (SSPs). He then introduced the objectives of the 2015 IAMC meeting: providing an overview on the current state of the art of IAM research in a number of oral and poster sessions comprising more than 80 presentations; discussing future research priorities; and providing an update and collecting feedback on the work of the Scientific Working Groups and governance and institutional matters of the IAMC. He pointed out that the IAMC meeting has grown again in size and outreach compared to the previous annual meeting, with now 140 participants and 85 abstract submissions.

THE ROAD TO PARIS AND BEYOND – WHERE DO WE STAND ON INDCS, WHAT IS THE FUTURE ROLE FOR THE COMMUNITY IN ASSESSING INDCS?

Implementing the Paris outcome for realising the global transition to a low-emission climate-resilient economy

Miles Perry (DG Climate Action) outlined the role of IAMs in emerging climate policy, and a perspective on Paris from a scientific (and IAM) point of view. IAMs have a role across different scales: from pure science, technology considerations, economics, to societal and behavioural change. This is relevant for the near term and the long term, for discussions on the EU Energy Union, the enabling conditions for innovation and societal change, global negotiations, ongoing climate issues like impacts, nonlinearities, sustainable development goals, and finally, climate neutrality.

A Paris agreement may require IAMs to consider combined emissions and temperature goals. It may also require IAMs to inform global stocktaking and updating cycles as well as support reporting and review of emissions. Generally, the draft of the Paris agreement frequently mentions the imperative to use the "best available science" and there may be a Special Report in the AR6 cycle on decarbonisation pathways and 1.5 °C impacts.

In summary, the many different targets in the INDCs stress the need for technical expertise to build a global perspective and thus call for regular IAM contributions.

In the Q&A session, Mr. Perry stressed that Paris will probably at least include transparency requirements and an update mechanism. He also clarified that the proposal on having a Special Report on decarbonisation is no official EU position.

The INDC assessment of the UNEP Gap Emissions Report 2015

Michel den Elzen (PBL) presented two analyses on the INDC pledges: an analysis on the global level developed for the UNEP Gap Report 2015 based on multi-studies and an analysis on the national level as summarised by a new PBL report (www.pbl.nl/en).

The UNEP report assesses 119 INDCs, uses official sources and eight global studies. It shows that with the full implementation of INDCs, the emissions gap in 2030 with a cost-effective pathway to keep the global temperature increase below 2 °C is still around 12-14 GtCO2eq (cost-optimal reductions starting in 2020). It points at challenges, such as different target specifications, and the dependency of some INDCs on international funding.

The PBL report comes to a similar result on the 2030 global gap, and also includes national INDCs assessments. The presented analysis of individual INDCs shows how INDC implementation could enable a transition from business-as-usual trends to lower emission levels, lower emissions per capita and lower emission intensities at both national and global levels.

In the Q&A session, participants hinted at uncertainties in emission inventories. Mr. den Elzen made clear that some of the studies analysed by PBL show emission peaks in China already in

2025 and 2030. He also confirmed that the start of ambitious policy has substantial influence on the emissions gap and stressed the increase of costs and risks connected to a delay in climate policy.

Implications of the INDCs for reaching long term climate policy objectives

Christoph Bertram (PIK) talked about the challenges of delayed mitigation action. Such delay would lead to early excess emissions from a carbon lock-in and insufficient ramp-up of alternative energies, and the need for more rapid emission reductions in the medium term, and more stringent policies in the long term. It would also imply reduced co-benefits and faster warming in the near to medium term. The cost increases due to delay (especially the - very policy relevant - transitional costs) raise questions of distributional and political feasibility. Policies to counteract the lock-in in the near term include low-carbon support, restrictions on the construction of coal-fired power plants, and cutting back final energy subsidies. Among INDC proposals, there is no commitment to carbon price signals, but a lot of renewable energy support and some regulation of high carbon energy. Carbon pricing signals would be very important though to gain experience with pricing systems, as a potential source for climate finance, and to achieve some comparability of efforts between countries. Anticipation of future carbon pricing was shown to smooth emissions paths.

To a question from the audience, Mr. Bertram clarified that double accounting of overlapping policies should not be problematic as the current bottom-up process in international negotiations would already benefit from policy coordination even without harmonization or one-to-one comparability. One of the participants remarked that most of today's plans for new coal-fired power plants are state-controlled - a contradiction to ambitious climate policy of the same states.

Panel discussion: How useful and relevant was the work of the IAM community for the Paris negotiations, and what insights are sought from the IAM community for the post-Paris process?

Allen Fawcett (EPA) talked about how IAMs were crucial in understanding each other's mitigation potential, and in some sense pushing each other, in the run-up to the joint U.S.-China announcement on climate action in 2014. Mr. Fawcett noted that today's action gap in climate policy is sobering, and understanding the tangible benefits from climate policy is crucial for the updating and strengthening cycle of international climate policy. IAMs could inform those policy decisions, and have a large role in constructing the narratives for futures under different warming scenarios.

Roberto Schaeffer (COPPE) stressed that the Brazilian INDC was significantly informed by IAMs. At the global level, reliance of both the SRREN and AR5 reports on IAMs has influenced the way climate policy is made. Mr. Schaeffer hinted at areas of improvement for IAMs, especially the cost bias due to missing climate impact representations in models.

Ritu Mathur (TERI) raised attention to the gap between the modelling of global climate policy, and the understanding of policies and distributional impacts at the national level. For India in particular it is important to understand technology diffusion, lock-ins, and the co-benefits of climate policy. Better linking science and policy making is important.

Miles Perry (DG Climate Action) talked about how decisions at the EU level have been informed by IAM analysis for quite a while, the importance of including co-benefits, and the question of how to enable non-state actors to make meaningful contributions to mitigation. Mr. Perry stated that concepts from IAMs have found their way into the policy discussion, and the idea of 'bridging' between the INDCs and 2 degree trajectories should and would do so too. **Toshihiko Masui (NIES)** talked about how IAMs have been used to inform policy in Japan since 2008, even though the INDC contribution was not much informed by it. Mr. Masui sees the role of IAMs in bridging policy making and science, and sees areas ripe for improvement in local scale assessment, the provision of information with respect to long term targets. He stressed that immediate climate action has to be informed by IAMs, and developing countries could be supported more through capacity building in modelling capabilities.

Jiang Kejun (ERI) discussed how China recently strengthened its INDC targets for wind and solar power, and stressed the importance of local air pollution. Mr. Kejun mentioned how policies targeting local air pollution may lead to an earlier peak in Chinas CO2 emissions. Future requirements for IAMs include a better representation of the INDCs.

In the open discussion, Roberto Schaeffer mentioned that the projects MILES and CD-LINKS helped by connecting national modelling teams and IAM modellers, and Ritu Mathur remarked that feedbacks from IAM results at national level, e.g. technology diffusion patterns, are still to be explored, and Jiang Kejun agreed to the importance of national studies for increasing the ambition of the INDCs. Allen Fawcett still expects significant co-benefits on reduced air pollution of climate policy in the U.S., even though many dedicated policies targeting air pollution are in place - such that air pollution and climate policy have to be modelled jointly. Toshihiko Masui added that ecosystem services, water pollution, and in Japan especially health issues are important co-benefits as well.

HOW TO USE THE NEW CLIMATE CHANGE (SSP-RCP) SCENARIOS IN FUTURE IAM, IAV AND CLIMATE MODELLING STUDIES?

Overview and status of the SSP scenario process

In the presentation "Overview and status of the SSP scenario process", **Detlef van Vuuren (PBL)** outlined the key role of scenarios for climate research, e.g. their contribution to the IPCC WG 1-3. The SSP scenarios combine socio-economic and climate information and draw five worlds: SSP1- Sustainability, SSP2 – Middle of the road, SSP3 – Regional Rivalry, SSP4 – Inequality, SSP5 – Fossil-fuelled Development. A SSP Special Issue is planned to be published in the first half of 2016 with a focus on a) narratives and socio-economic drivers (GDP, population and urbanization) and b) IAM results based on the SSPs process (overview, energy, land-use, Aerosols/Air pollution). SSPs are ready for use by other communities and are already now used in several research projects (e.g. CD-Links).

scenarioMIP and other CMIP6 activities

Brian O'Neill (NCAR) illustrated in his presentation on "ScenarioMIP and other CMIP6 activities" how ScenarioMIP plans to use SSPs to generate the next round of climate scenarios. The scenario design by ScenarioMIP plays two roles: 1.) facilitating integrated research across climate science, IAM and the IAV community, 2.) addressing specific climate science questions related to the climate response to anthropogenic forcing. The existing RCPs will be updated based on the SSPs, and two new forcing levels (3.4 W/m2 and 7 W/m2) will be added. The

addition of a new low forcing scenario below RCP26 has been recommended if IAMs can produce such a scenario. Specific SSP-based scenarios were selected according to the following criteria: facilitation of climate results (e.g. a strong signal in terms of land use or aerosol emissions); relevance for IAM/IAV studies; and minimizing differences in regional forcing between the chosen scenario and other SSPs. Remaining issues to be resolved in the ScenarioMIP design include identification of a suitable SSP for the 6.0 W/m2 forcing level, the design of an overshoot scenario, and finalization of details of long-term extensions until 2300. Beyond finalizing the design, next steps include ensuring the provision of historic data and harmonized IAM emissions and land use scenarios, and coordination of GCM simulations at the beginning of 2017.

In the following Q&A round the audience investigated plans to integrate short term developments and links to the INDCs. Detlef van Vuuren pointed at several studies based on SSP2 scenarios. The audience also asked questions on the downscaling of SSPs. While preliminary results for downscaled population are available, downscaling of GDP has not yet been carried out (although some modelling groups have interest in doing so).

The question on how to include urbanization in the SSP process was raised. In IAMs urbanization plays a role for the energy share and the urban population share by country is part of the available information for each SSP.

AgMIP and ISI-MIP perspective

Hermann Lotze-Campen (PIK) outlined the "AgMIP and ISI-MIP perspective" on the SSPs. AgMIP links global economy models and landuse and tries to emphasize the interaction between global and local/regional processes. All involved models use SSPs/RCPs to generate RAPs. In regional assessment terms AgMIP wants to get feedback from the regional studies to downscaled model output. Bridging global RAPs/regional RAPs to other models (e.g. food security) is work in progress. ISI-MIP started with a fast track model comparison of impact models. ISI-MIP2 includes regional models, will focus on extreme events and more sectors, including cross-sectoral effects. The next step will be a modular climate-impacts portal 'Impacts-To-Go' to access climate impact projections and emulators with an option for multi-sector analysis. In the discussion that followed, the audience asked about how the 'Impacts-To-Go' would be designed for user defined scenarios. Hermann Lotze-Campen replied that the range of climate impacts and SSPs is still to be discussed.

Results of the IPCC scenario meeting and future scenario process

Keywan Riahi (IIASA) gave a talk on "Results of the IPCC scenario meeting and future scenario process". About 110 people attended the IPCC expert meeting in May 2015 at IIASA. Significant progress was made in the parallel scenario process including RCPs, SSPs and ScenarioMIP. The objectives of the meeting were to launch the SSPs and share information about ongoing activities and future work, to identify needs/gaps and to discuss the role of scenarios for the IPCC. During the AR5 scenarios played an important role across research communities. The global SSPs were launched and regional and sectoral extensions, participation in bottom-up scenario process and the next generation of climate runs were discussed. Still there is a debate on whether the whole range of plausible future forcings is covered already. The key recommendations for the IPCC are: a) to prepare ahead of the AR6 scenarios and interaction between adaptation, mitigation and impacts, b) assure integrative role of scenarios, c) IPCC expert meetings to facilitate county-wide exchange, d) support developing country researchers

to participate, e) pursuit synergies with other organizations (e.g. IPBES, UNEP/GEO, etc.). The recommendations for the community are: a) further develop SSPs as a toolkit, b) represent uncertainty, c) ensure flexibility and openness of the scenario process, d) best practice guide for users of scenarios, d) a communication strategy.

Discussion on ways for IA community to contribute to scenario process
Keywan Riahi explained that compared to SRES scenarios, SSPs can be updated thanks to their toolkit-function. The audience mentioned the importance of involving users and investigating their needs (e.g. interviews). Keywan Riahi suggested IAMC participants may think about the involvement of national communities, considering that the SSP framework is also useful for the INDCs. From the audience came the suggestion to contact the new chairs for IPCC recommendations.

PARALLEL SESSION: ANALYSIS OF CLIMATE CHANGE AND CLIMATE IMPACTS IN IAM APPLICATIONS

Chairs: Kate Calvin (PNNL), Juan-Carlos Ciscar (JRC-IPTS), Tom Kram (PBL)

Searching for the weak spot– A comprehensive investigation of climate change impacts and macroeconomic growth
Franziska Piontek (PIK) showed that current global damage functions are too aggregate, too low, and not well suited to capture long-term growth effects. She followed a different approach, which is used by other studies that do not only consider GDP, but also e.g. total factor productivity (TFP), capital depreciation rate, labour. Single shock experiments with damage affecting only one channel showed different impacts on channels, with TFP most affected. Damages increase (also in the long-term) if endogenous growth is considered. In future work, CES production functions instead of Cobb-Douglas are to be considered, which are expected to lead to higher damages due to less substitutability.
In the following discussion, the question was raised whether this approach is consistent with the empirical literature. It was also pointed out that adaptation measures could strongly affect damage curves. However, liquidity constraints might reduce adaptation capabilities.

Economic impacts of climate change on human health through undernourishment
Tomoko Hasegawa (NIES) outlined how climate change affects the economy through undernourishment. Childhood underweight is the top risk factor of disability in low income regions. This work builds in previous studies that showed that the risk of hunger is relatively low in SSP1,2,5, and higher in SSP3,4 (Hasegawa, ERL 2015). Without climate policy, the risk of hunger is increased through climate change impact on agricultural yields. With climate policy, the impact on yields is lower, but mitigation costs and bioenergy effects lead to a higher total risk for mitigation scenarios. In her current work, Mrs. Hasegawa looks at direct economic impacts of decrease in labour force and population and healthcare costs, and indirect economic impacts of values of lives lost. She compared SSP2 and SSP3, each with RCP2.6, 8.5, and no climate change. Impacts were heterogeneous among regions, with largest impacts occurring in India, South Asia, Sub-Sahara Africa. It turned out that indirect economic impacts due to mortality were much higher than direct economic impacts.
In the following discussion it was pointed out that the concept of the statistical value of a life (SVL) has caused a lot of discussions after SAR, and should be used very carefully. Questions were raised on whether trade and crop switching play an important role and whether crops

not included in ISI-MIP were considered. Both, adaptation measures and other important crops are planned to be included in the future.

Avoiding the impacts of climate change: Results from the BRACE study

Brian O'Neill (NCAR) showed results from the BRACE (Benefits of Reduced Anthropogenic Climate changE) study. They analysed the difference in physical and societal impacts between RCP8.5 and 4.5 for SSP3 and 5. A study on heat waves that distinguishes between urban and rural showed that mitigation halves the global population exposed to heat waves. Avoided heat extremes occur as early as 2020-2030 for some regions. When including CO2 fertilization, aggregate yield is actually higher in RCP8.5 than in RCP4.5 (no direct effect of heat waves considered). A concentration of avoided impacts was found for the Amazon and European regions. The effect of societal development (SSPs) was found to be larger than the effect of climate (RCPs) for a number of impacts.

The discussion following the presentation focused on the question whether costs of avoided damages can be calculated.

On the consequences of constraining water to energy and land use

Mohamed Hejazi (PNNL) outlined how GCAM tracks water demands for several sectors, subsectors, and technologies at various spatial scales. He showed that a constraint on water could reduce global water withdrawal by ~20%. The largest uncertainty in water runoff comes from groundwater estimates. A constraint on water withdrawal might lead to higher demand for desalinated water and therefore higher energy demand. Adaptive decisions to water scarcity will alter agricultural and land use patterns, which lead to a shift in wheat production from MEA to EUR, CHN, USA. Climate policy has little effect on global water withdrawal. Higher demand for irrigation (primarily due to biomass) and lower demand for electricity sector cancel each other.

In the following discussions the question was raised whether water temperature was accounted for. This is planned, but not done yet. Costs for water differ between sectors, farmers usually pay less. In the model, this is accounted for by assuming that farmers pay only a certain percentage. What if desalination became very cheap due to low electricity prices? Desalination provides only small fraction of demand, but feedback to energy sector is not included.

Confronting and reducing future risks in Water-Energy-Land Systems

Adam Schlosser (MIT) talked about confronting and reducing future risks in water-energy-land systems. He presented work done with their Integrated Global System Model (IGSM) linked to the Water Resource System framework (WRS), in order to estimate various water related indicators, such as water stress and unmet demand, in a river basin scale and across different scenarios related to changes in climate, socio-economic growth, and adaptation. The results indicate that by 2050 unimpeded climate change will bring a greater likelihood of decreased runoff across most basins and cause widespread increases in irrigation requirements. Climate change mitigation policies can substantially reduce the likelihood of nations trending into extreme water-stress, while economic growth is also an important factor. Adaptation infrastructure is cost-effective and can reduce and reverse risks of unmet water demands.

Interactions between Climate Change Mitigation and Adaptation in Energy Scenarios for Brazil

The talk of **Andre Lucena (PPE/COPPE/UFRU)** focused on climate change impacts on hydropower generation and interactions between climate change mitigation and adaptation in

energy scenarios for Brazil. He gave an overview of the Brazilian interconnected hydropower system, and then, using the RCP8.5 and 4.5 scenarios and the HadGEM and MIROC Global Circulation Models (GCMs), he presented the impacts of climate change on this system and the interplay between adaptation versus mitigation alternatives. According to the presented results, projected river flows are negatively affected under climate change scenarios for both GCMs. Operation costs increase dramatically with climate change impacts, and are higher for HAdGEM and RCP 8.5. Gas and coal fill in the gap of reduced hydropower capacity in the absence of a carbon price, and a portfolio of renewables (wind, solar, biomass) when a carbon price is imposed. An important conclusion of the study was that mitigation policies impact optimal adaptation strategies, and it is cheaper to mitigate to avoid high impacts as opposed to alloying for high impacts and adapting to those.

The economic consequences of climate change to 2060

Rob Dellink (OECD) outlined the economic consequences of climate change to 2060. The work is part of the CIRCLE project, and currently focuses on the costs of inaction but the aim is to also include co-benefits. The study used a multi-sectoral multi-regional general equilibrium model to calculate future macro-economic costs of environmental damages on the economy. The considered effects include impacts on agriculture, coastal zones, energy demand, health, tourism demand, capital damages from hurricanes, fatalities from heat waves, urban damages, and biodiversity, but not large-scale disruptive effects. There is a significant damage at a global scale, but Asia and Africa are more severely affected. Global damages were major for health (labor productivity impacts) and agriculture (without CO2 fertilization). Urban flood damages can have huge impacts in India and China. Costs from biodiversity losses (based on a willingness to pay approach), where at 1% of GDP loss for OECD countries, and less for non-OECD countries due to lower willingness to pay. Policy controls enforcing climate change mitigation help in reducing damages. Damage costs increase more than proportionally with temperature. Both adaptation and mitigation policies are needed.

Estimating Global Damages from Sea Level Rise with the Coastal Impact and Adaptation Model (CIAM)

Delavane Diaz (EPRI) presented a way of estimating global damages from sea level rise with the Coastal Impact and Adaptation Model (CIAM). She first gave an overview of what causes sea level rise (thermal expansion, land ice melting, and local factors such as ocean dynamics, tectonics, etc.) and showed that mitigation alone does not resolve sea level rise problems (in 2100 that is 45cm in RCP2.6 and 75cm in RCP8.5), so adaptation measures such as protecting or retreating from the coast are very important. She used CIAM to understand coastal impacts and adaptation at the local level, and developed new damage functions for sea level rise using information also from the DIVA model. Adaptation can reduce global costs by a factor of ten, and adaptation should start irrespective of climate change mitigation efforts. Retreating from coastal areas appears to be the optimal response in most cases, as opposed to protecting the coast. An important conclusion was that damage costs may not be as high as other models predict. A question was raised on the interactions across coastal segments, which are at the moment not considered in the model where each coastal segment is treated independently. A second question led to the clarification that the economic loss of properties next to the coast does not show up because it is transferred to other land properties upstream but that distributional issues do exist. Finally, it was explained that interactions with other sectors (such as agricultural land) are not considered, and land is valued at the current GTAP land rate.

In **the concluding discussion** that followed, the session moderator (Tom Kram, PBL) reflected on the extent to which the different SSP-RCP combinations are relevant for further climate change impacts. Most models departed from an RCP 8.5 that seems to be at the edge of the imaginable, therefore going below RCP 8.5 might make results more relevant in the policy arena. The same applies for the SSP combinations, i.e. it might be useful to analyse less extreme scenarios than SSP5 or SSP3. The coverage of adaptation was also raised as an important issue. A response to that was that it might be too early to assess whether RCP 8.5 is a very unlikely outcome. The issue that the impacts of anticipation via redirection of investment flows can be important for adaptation was also raised. A last comment was that going into more sectoral and spatial detail, will make distributional impacts important (e.g. housing and sea level rise effects) and our ability to assess climate change effects will become more and more challenging.

PARALLEL SESSION: UNCERTAINTY AND THE USE OF IAM PROJECTIONS

Chairs: Leon Clarke (PNNL), John Weyant (U Stanford), Steve Rose (EPRI)

Modelling to generate alternatives: A technique to explore uncertainty in integrated assessment models

James Price (UCL) outlined two types of uncertainties, namely, Input parameter uncertainty, and structural uncertainty. To analyse the size of uncertainty, MGA (Model generating alternatives) procedure is employed, which seeks to map the near optimal solution space of the unperturbed model and in this way explore the diversity of different energy systems that lie within. The study described and demonstrated a technique to explore the near optimal solution space of a linear optimization IAM for the purposes of uncertainty analysis. The method is complementary to traditional Monte-Carlo approaches and, additionally, takes an initial step toward accounting for structural uncertainties within the models formulation (in this case that decision makers may not function in a cost optimal way).

A methodology to investigate the uncertainty of scenario drivers and the diversity of socio-economic pathways with similar outcomes

Celine Guivarch (CIRED) outlined a methodology to find diversity of socio-economic pathways with similar outcomes. To understand the uncertainty in the scenarios drivers leading to a specific outcome, the approach contains steps as follows: Identify a priori the main driving forces, translate them into a model parameters with alternative values, build a large number of model runs, combining the alternative values for parameters, to explore social-economic uncertainties. In an example application, this approach led to ~400 scenarios. Select a subset of scenarios, and use a scenario discovery cluster analysis (eg Prim algorithm implementation in sdtoolkit 2.3 package for R) to identify the combination of drivers characterizing the subset of scenarios of interest. Iterate the selected scenario, and find a second family of scenarios until the density of the scenario is lower than 50%. The study demonstrates the methodology with two applications. The first example focuses on scenarios with high cumulative CO2 emissions. These results highlight those high emissions scenarios are not necessarily associated with high per capita GDP growth, but can be associated with relatively low per capita GDP growth, if counterbalanced by high population growth and/or slow energy intensity improvement. The second application focuses on the SSP4 domain, of “high challenges to adaptation” and “low challenges to mitigation”, from the Shared Socioeconomic Pathways (SSP) framework. The results show that several different combinations of drivers can lead to similar outputs in

emissions and per capita GDP growth in low-income countries. In particular, combinations of drivers with either high productivity catch-up and/or high leader productivity growth exist in the SSP4 domain.

Climate policy under socio-economic scenario uncertainty

Johannes Emmerling (FEEM) outlined uncertainty with associated socio-economic pathways together with climate policy. Their study indicates the role of uncertainty about the baseline drivers of the economy, namely population and GDP, for the determination of the optimal climate policy and assesses how robust decisions can be taken facing this baseline uncertainty. The study makes use of a new set of Shared Socio-economic Pathways (SSPs) to assess the range and hence uncertainty of future baseline growth and population assumptions. Firstly, it estimates the cost of this uncertainty from a decision maker's perspective and show how different decision rules for the optimal climate policy under baseline uncertainty can be applied. Secondly, they discuss how measures of the costs of climate change induced impacts and climate change policy costs can be measured and compared with uncertain baselines.

UK electricity system modeling 1990-2014 and the (im)possible mission of embracing parametric and structural uncertainties

Evelian Truthevyte (ETH Zürich) outlined how to deal with parametric and structural uncertainties in a national energy system model, which is a bottom-up cost optimization model. Modeling the past to understand the uncertainty in the cost minimization model. There are two types of model approach as follows: 1) social planners' perspective; 2) partial equilibrium approach. Compare simulation outputs from cost-optimal scenario v.s. real-world transition.500 runs of Monte Carlo mode to see the parametric uncertainty are implemented. Then slack mode is employed, e.g, 17% or 23% near to the optimal solution with deterministic runs. Then 250 slack scenarios with 500 Monte Carlo runs are used to analyse patterns in a large number of scenarios with maximally different scenarios. The study shows that cost optimization with perfect foresight does not necessarily approximate the real world transition, while near optimal scenario can encapsulate the real-world transition.

Climate policy as risk management

Geoffrey Blanford (EPRI) outlined stochastic programming. Perceptions of climate risks drive GDG regulations, yet little analysis informs risk trade-offs. Cost-benefit analysis with probability is used to illustrate risk management analysis with MERGE model in terms of damage functions and climate uncertainties. Three types of damage functions based on FUND, DICE, Weitzman and three types of climate scenarios are derived for the analysis to specify the probability of the related damage function, which is then put into a stochastic model.

Next steps in uncertainty analysis for the IAM community: Lessons from the IPCC scenarios database

Bas van Ruijven (NCAR) presented an analysis of the IPCC AR5 scenario database. The goal was to explore what types of scenarios are included in the database, what characterizes the scenarios in the different categories and what conclusions can be drawn with the current version of the database. The study identified the number of scenarios in the AR5 database that include limitations in climate policy (e.g. delay or fragmentation), limitations in technology (e.g. CCS or bioenergy) and a combination of both. The analysis shows that there are considerable gaps, in particular for combined limitations. A result of the study is that it is hard to conclude

clearly that RCP4.5 is less sensitive to limitations in policy and technology than RCP2.6 and RCP3.7 given the lack of scenarios in the literature.

Exploring the feasibility of low-carbon scenarios using historical energy transitions analysis

Ajay Gambhir (Imperial College London) presented a study on the feasibility of 2-degree scenarios under consideration of stylized facts derived from historical energy transitions. The research question was: What can we learn from historical energy transitions for the feasibility of 2-degree scenarios? Based on past energy transitions, six stylized facts have been derived. For instance, growth curves tend to be S-shaped, technology rarely grows at more than 20% per year, and initial exponential growth shifts to linear growth in the longer term. Under such constraints, the costs for achieving a 2-degree target more than double. He concludes that the analysis of historical transition rates can only be a rough guide to the future, since there can be (and have been) very rapid short-term growth rates in individual technologies and energy resources in specific regions.

Global energy model hindcasting and validation

Shinichiro Fujimori (NIES) presented a study with the AIM/CGE model focusing on validation. There are multiple approaches to evaluate the validity of IAMs. One of these approaches is hindcasting. In contrast to forecasting by simulating the future, this method simulates the historical period. Other approaches for validation involve scenario-based diagnostic model runs or model documentation. Here, primary energy was validated by comparing simulations of the AIM/CGE model for the period 1981 to 2010 with statistics. At the global level results of primary energy compare well to statistical data but at the regional level historical simulations of primary energy and statistical data disagree.

Comparing future patterns of energy system change in 2°C scenarios with historically observed rates of change

Mariesse van Sluisveld (PBL) presented a study that compares modelled rates of change in 2-degree scenarios to historically observed rates of change. The study employs data from several IAM teams that participated in the LIMITS project. Modelled and observed rates of change are analysed for technology expansion and diffusion, emissions and energy supply investments. Absolute rates of change become rapid in the medium term compared to historical figures, while relative rates of change find future change to be broadly within historical ranges. But none of the indicators provides conclusive insights as to the achievability of 2-degree scenarios.

POSTER SESSION

Chairs: Volker Krey (IIASA), Gunnar Luderer (PIK), Roberto Schaeffer (COPPE), Narasimha Rao (IIASA), Bas van Ruijven (NCAR)

A specific session in the evening of November 16 was dedicated to the presentation of overall 44 posters covering the following 11 thematic areas:

1. Analysis of climate change and climate impacts in IAM applications
2. New IAM analyses on the climate policy – sustainable development nexus
3. Analyses of distributional impacts of mitigation pathways and/or climate change
4. Uncertainty and the use of IAM projections
5. Modelling Tools

6. Integrated assessment of INDC proposals and their implications for global emissions
7. Integration of variable renewable energy
8. Transport modelling
9. Fossil fuel resources and technologies
10. Analyses of the low carbon transformation
11. Integrated assessment of climate engineering and carbon dioxide removal technologies

Posters presented during the session are included in Annex III of this report.

DAY 2: TUESDAY, NOVEMBER 17, 2015

PARALLEL SESSION: FROM CLIMATE POLICY TO BROADER SUSTAINABLE DEVELOPMENT ANALYSIS: NEW IAM ANALYSES ON THE CLIMATE POLICY – SUSTAINABLE DEVELOPMENT NEXUS

Chairs: Keywan Riahi (IIASA), Detlef van Vuuren (PBL), Bas van Ruijven (NCAR)

Pathways to achieve a set of ambitious global sustainability objectives by 2050: Explorations using the IMAGE integrated assessment model
Detlef van Vuuren (PBL) presented a PBL study that analysis three different strategies for achieving multiple sustainable development targets, such as the below 2°C target, MDGs and biodiversity conservation, with a focus on exploring synergies and trade-offs (published in TFSC 2015, doi:10.1016/j.techfore.2015.03.005). The three pathways explored until 2050 are: global technology, decentralized solutions and consumption change. Some targets could be reached with all pathways; others (e.g. nitrogen) could not be reached at all or would be very difficult to reach with all of the strategies (water stress). As a follow-up, PBL is currently looking into implications of the new Sustainable Development Goals. In the Q&A session, the following issues were brought up: the water issue, the importance of adaptation strategies, the potentially problematic time frame of 2030 of the SDGs as well as the role of model intercomparison studies in addressing these issues. It was stressed that the SDG process is an open process and that results from a diverse set of models can help improve formulation of SDG targets.

Using the International Futures Model to enhance the socio-econonomic representation of the Shared Socioeconomic Pathways (SSPs) for understanding challenges to adaptation
Dale Rothman (University of Denver) talked about the internal consistency of drivers of SSPs which have been provided by different groups. They used the model International Futures for performing a consistency check. This hybrid model (some similarities to CGE) has detailed representations of education, economics, health and demographics, with more stylized representations of other sectors. They put in SSPs drivers from the SSP database and adjusted other parameters to SSP narratives. Their results show that many of the SDGs will not be reached in any of the SSPs. They have a richness of indicators on country level (HDI, poverty, undernourishment, access to sanitation, governance). In the Q&A session it was discussed whether or not the governance indicators can give information on cost mark-ups for technologies and while this is a possibility, some more ground-work is needed for better understanding.

Can Paris deal boost SDGs achievement? An assessment of climate-sustainability co-benefits
Lorenza Campagnolo (FEEM) presented a CGE analysis of extreme poverty (SDG1) and inequality (SDG 10). Lorenza Campagnolo reviewed different potential drivers for poverty and inequality growth (GDP per capita, Gini index, education expenditure share of GDP and sectoral value added shares) and used panel regressions with time and country fixed effects to find determinants of inequality and poverty, using WDI database (WB) from 1990 – 2012. The estimated elasticities are used in ICES model to project inequality and poverty in the SSP2 scenario up to 2030. In the baseline, inequality increased (on average 8% increase of GINI index) but poverty decreased due to the rise of GDP per capita. Furthermore a climate policy, based on INDCs is analysed, resulting in 36% lower emissions in 2030 and very mixed results in terms of GDP (negative for countries with INDCs, positive for countries with no binding INDCs). Lorenza Campagnolo distinguished an INDC case with and without a development fund, reaching 109bn$ in 2030. The climate policy with and without the fund determines no change in inequality and a small decrease of extreme poverty. Future research will look into different recycling schemes and more indicators. In the discussion, Lorenza Campagnolo explained that the inequality change depends on sectoral value added evolution and expenditure on education whereas poverty dynamics depend positively on GDP per capita and negatively on inequality variations.

Environmental impacts of alternative power sector decarbonisation strategies
Gunnar Luderer (PIK) presented work-in-progress in the EU-funded project ADVANCE on integrating life-cycle analysis (LCA) in IAM to analyse the environmental co-benefits and adverse side-effects of different power sector decarbonisation options, as well as resource bottlenecks. Researchers analysed 4 scenarios (base, FullTech-Pol, Conventional-Pol, Ren-Pol) in 3 models (REMIND, POLES, IMAGE) and used tailor-made prospective life-cycle coefficients for emissions, water, land, other pollutants and resource indicators. The results highlight the importance of using dynamic instead of static coefficients as so far used (e.g. in AR5), so that in 2050 direct CO2 emissions by far dominate overall CO2 emissions. An integrated picture of all considered indicators shows how conventional decarbonisation focusing on CCS and nuclear has much higher environmental impacts while a strategy focusing on renewables has higher raw materials requirements, and a full portfolio balancing these two broad impact categories. The Q&A session discussed system boundaries and disaggregation of the analysis, e.g. in terms of different coal mining options.

Will climate mitigation affect the energy poor? Synergies and tradeoffs between climate mitigation and universal clean cooking access goals.
Kevin Ummel (IIASA) summarized a forthcoming study on household solid fuel use in South Asia (Cameron et al.), and presented a data initiative as well as a research idea. The study discusses the effect of mitigation on household solid fuel use and the efficiency of countervailing “access policies”, based on the iteratively coupled MESSAGE-Access model. A 30$ C-tax could result in 340 million additional solid fuel users by 2030, mainly from moderate poor rural households. The direct cost of reversing this effect is only 3-10$ billion per year, but the cost of SDG (90% clean fuel access) increases by ~12$ billion per year, while the exact choice of energy access policy is still the more important determinant. Currently the approach is expanded by calibrating to more regions, which involves the development of a unique database of household survey data relating to energy use.

Lastly, the idea of continuous household income distribution and distributional downscaling of SSP projections was presented. Potentially, models based on such continuous data may be more realistic than from binned distribution, plus the output results can be presented in any politically relevant way. In the Q&A session the issue of electricity access was raised, going beyond the definition of one lightbulb as access.

Modeling the energy-water-food nexus: A review of the opportunities and challenges for integrated assessment modeling

Nils Johnson (IIASA) presented an overview of studies dealing with water-energy-land-use modelling. He noted that literature investigating the interplay between these three topics altogether was quite scarce. Yet energy, water and land-use are characterized by many cross-dependencies pertaining to bioenergy, conveyance infrastructure, financial and institutional capacity, environment quality (*eg.* energy-intensive desalination may alleviate water-stress). However, water requirements in IAMs have been so far studied in a post processing fashion, and do not represent endogenously the water constraints. In order to study these interactions, a combination of hydrological, agro-ecosystem, land-use and energy models is necessary. Nils Johnson pointed to a couple of challenges among which the different spatial and temporal scales of these models and the absence of hydro-economic models. In the Q&A session, it was recalled that ISI-MIP also dealt with these issues. One participant related the absence of hydro-economic models to the fact that water was not treated as a commodity. Nils Johnson underlined the importance of better representing the technological developments in the water sector, with the help of economic reasoning.

Water demand for energy and food: a nexus analysis based on the Shared Socioeconomic Pathways

Next, **Ioanna Mouratiadou (PIK)** investigated the influence of mitigation policies, socio-economic drivers and water policies on future water demand, using the LPJmL-MAgPIE-REMIND-MAGICC modelling framework. Ambitious mitigation policy causes a doubling of agricultural water demand compared to today's level, due to higher bioenergy production on irrigated land. This trend is slightly counter-acted by the replacement of thermal by renewable technologies for power generation, the latter being less water-intensive. As for the effect of socio-economic drivers, additional water demand for bioenergy under climate policy is twice as high in SSP5 compared to SSP1. Electricity water demand is lower under climate policy for SSP1 and SSP2 but higher for SSP5, due to a higher deployment of nuclear that is very water intensive. Finally, policies on the restriction of irrigated bioenergy and a transition away from once-through cooling systems towards recirculating and dry cooling systems have a major influence on the results. In the Q&A, the first question was on the effects of restricting irrigation for bioenergy demand and prices, a second on the role of CCS, and the third one on the role of hydropower. Ioanna Mouratiadou answered that the effect was important for prices but not significant for bioenergy demand due to the high carbon price. Additional water demand for CCS is considered but CCS shares are not significant in the results. The role of hydropower is intricate because there is a lot of uncertainty on the associated water demand so more community work is needed in this direction.

Economic impacts of the land-water-energy nexus

Fritz Hellmann (PBL) presented his analysis of the feedback of environmental damages on growth, focusing on the ground water availability. His work is the result of collaboration between PBL and OECD, within the CIRCLE project. Fritz Hellmann first noticed that the

feedback of environmental damages on growth was only poorly studied thus far. To address this issue, the ENV-Linkages model provided growth trajectories for several sectors to the IMAGE model. The latter computed biophysical impacts out of these trajectories and of assumptions on the ground water availability. As a result, crop yields were positively or negatively affected depending upon the regions. These new crop yields were used in the ENV-Linkage for analyzing the effects on growth of biophysical damages. In this framing, the impact of environmental damage on economic growth was found to be small globally, but unevenly distributed across regions. India and Northern Africa were predicted to experience the largest damages. In the Q&A session, one participant asked for the number of loop iterations between both models. Because of the small GDP effect, one iteration was considered as sufficient.

Socioeconomic development, climate change, and regional food security

Stephanie Waldhoff (PNNL) evaluated the impact of socio-economic drivers, climate change and food-price variability on food access and availability. Food security has evolved positively over the last decades. However the improvement is not universal and some countries followed declining trends. Stephanie Waldhoff and colleagues developed a method to estimate regionally-specific consumer prices from modeled producer prices and a metric of food security, which are used to investigate the impact of different population and GDP development trajectories, as quantified in the SSPs, using the GCAM model. In all SSPs, food access and availability in 2050 improves compared to 2010 values. Including the role of price volatility, which may worsen as climate change increases the frequency and severity of drought, eliminates the projected improvement in food security conditions for some regions with many regions remaining vulnerable to variability in staple food prices. In the Q&A, the role of migration triggered by food stress and its consistency with the SSP scenarios was discussed.

The following discussion covered both sessions on the sustainable development goals and on the interaction between economy, energy and natural systems. During the vivid discussion, a couple of priorities emerged to be considered for the research agenda:

- Scale of the studies: As IAMs develop, they go further away from strictly global problems such as climate change to study local issues such as water availability, land-use, health impacts, etc. Among others, this poses the question of the feedback of local impacts on the global level. Currently, most IAMs deal with local issues by post-processing their results, hence missing this feedback,
- Income distribution might be strongly affected by mitigation policy and also determine the feasibility of mitigation policies. Yet, it is only poorly represented in many IAMs,
- Health issues: they have already been studied within the ISI-MIP, from the climate perspective. Collaboration with ISI-MIP on this question raised some interest.
- Population projections and migration: some studies showed water scarcity in some regions due to high population projections. However these projections might be inconsistent with the scarcity as the latter would trigger migration. This kind of effects might be interesting to study,
- Some participants called for model intercomparison projects in the IAM community that would deal with new, more local, topics such as health impacts, income distribution, etc.

PARALLEL SESSION: INTEGRATED ASSESSMENT OF CLIMATE ENGINEERING AND CARBON DIOXIDE REMOVAL TECHNOLOGIES

Chairs: Massimo Tavoni (FEEM), Elmar Kriegler (PIK)

Elmar Kriegler introduced this parallel session by highlighting the importance of recent discussions on negative emissions following the publication of the IPCC AR5. In particular, he stressed the heavy criticisms on the reliance on BECCS in 2°C scenarios which can be grouped in two categories: (i) It is claimed that BECCS has been introduced to lessen the need for mitigation to reach 2°C. (ii) It is claimed that BECCS has been introduced in IAMs to keep the 2°C in the political debate. This session provides an update on current research on climate engineering and carbon dioxide removal (CDR) and aims to shed some light on the on the potential and risks of the various climate engineering technologies.

The potential and limits of solar geoengineering and the trade-offs involved in substituting it for mitigation

Pete Irvine (IASS) gave an overview of the potential and limits to SRM. Focusing on a particular type of SRM: Stratospheric Aerosol Injection (SAI), he first emphasized the plausibility and low costs of this technology (1-10 Billion USD/Mt(species)/yr) that can reduce the risks of CO2 but also presented its side effects (and their impacts). These include an increase of diffuse light fraction (which can lead to increased vegetation production because light can better enter the canopy and decreased solar power productivity ~5%), changes to the stratosphere (which affect the chemistry and ozone loss), ocean acidification, CO2 effects on plants. Building upon this introduction to SRM, he presented how the different IPCC Working Groups (WG) work on SRM. In WG I, the GeoMIP project enabled researchers to better understand the climate effects of SRM. In short, SRM can effectively reduce the increase in temperature with little residual climate change at the regional level(slight overcooling in tropical regions, slight undercooling at high latitudes) but with a stronger impact on the hydrological cycle. Importantly he noted the limitations of precipitation as a proxy for the hydrological cycle impacts as runoff can increase whilst precipitation declines due to reduced evaporation. In WG II, there has been very little climate impact research on SRM. Pete Irvine highlighted the need to get the impacts community engaged in SRM. Regarding WG III, Pete Irvine emphasized the problems of representing SRM using simple metrics in IAMs. He mentioned that he is trying to get funding for a workshop on damage functions to be run in mid-2016.

In the following Q&A session, questions about the uncertainties on the impacts of using SRM and about its practical usage were asked. Pete Irvine acknowledged that large uncertainties exist but replied that they are ways to circumvent impacts to some extent. He disagreed on using SRM as a rapid quick fix “at the last minute” and would rather support an approach that gradually tests the response of the Earth system to SAI.

Geoengineering and climate agreements: a numerical assessment of the regional strategic incentives

Massimo Tavoni (FEEM) presented an analysis of the relationship between SRM and regional damage functions. In this study, the authors used the WITCH model in a Nash-game setting with a representation of SRM. They compared two types of regional damage functions: (i) one type that consider damages on GDP level (Tol et al, IPCC WGII) and (ii) and another type that consider damages on GDP growth (Dell et al, Burket et al). Massimo Tavoni highlighted that regional damages can be greater when GDP-growth based damaged functions are used and importantly the spread is very large, generating regional winners and losers. Allowing SRM

would reduce the regional spread in case of GDP-level based damage functions. In case of GDP-growth based damage functions, SRM reduces the spread but also make losers become winners.
In the following Q&A session, questions on the methodology (change in the game, the linearity of regional temperature to forcing) were raised. Massimo Tavoni agreed that it would be interesting to analyse the effects of solving the model in a full-cooperation game setting.

The role of carbon dioxide removal technologies for achieving long-term climate policy objectives: an analysis of the larger portfolio of CDR options
Jessica Strefler (PIK) presented an analysis of the carbon dioxide removal (CDR) portfolio using the REMIND and MAgPIE models. The CDR portfolio includes Bioenergy with CCS (BECCS), Afforestation (AFF), Direct Air Capture (DAC) and Enhanced Weathering (EW). She first highlighted the status quo, where only BECCS is available as a CDR technology. Without BECCS, less energy can be used and in particular fossil fuels have to be phased out earlier. The availability of BECCS reduces mitigation costs and balances mitigation costs across generations. She then presented the main differences between CDR technologies. BECCS and AFF have low costs but have to compete for land usage, whereas DAC and EW have the opposite characteristics. She reported that when both BECCS and AFF are available, they are deployed less due to land competition. Effects on food prices are quite dramatic, but can be reduced by allowing AFF in tropical areas only. Regarding EW, the potential is greatest in the tropical regions (Brasil, India and Southern Asia). Interestingly, EW is a complement technology rather than a subsitute. She presented a literature review on the techno-economic parameters of DAC. Since it is a relatively expensive option it will only be used in the last decades of the century. DAC could be interesting under very stringent climate policy scenarios (e.g. 1.5°C).
In the following Q&A session, Jessica Strefler highlighted that EW has also the potential to bring nutrients to crop fields.

Is Direct Atmospheric Capture the needed backstop technology for decarbonizing the global energy system or does it just complement BECCS?
Evangelos Panos (PSI) investigated the role of DAC for climate mitigation with the help of the MERGE-ETL model. As in the previous presentation, there are more emissions in the short term because of the perfect foresight feature of the model. Evangelos highlighted the significant reduction in shadow prices (which he found to be similar to a scenario with a target of 2.5°C). DAC is found to reduce mitigation costs by 30-35%. Looking at different burden sharing schemes (equalitarian, equal GDP losses, energy cost compensation), he reported that equal relative GDP losses appears to be a balanced burden sharing allocation.
In the following Q&A session, it came up that supply heat for DAC was generated from fossil fuels as a way to sustain the oil and gas markets, retain the value of oil and gas reserves and therefore enable the energy producers (Russia and Middle East) to participate in a global CO2 emission reduction protocol. It was suggested to consider RE based fuels such as hydrogen.

Sustainable land-use scenario toward negative emissions pathways
Etsushi Kato (IAE) discussed sustainable land-use scenarios towards negative emissions pathways explored with the GRAPE model. The model projects high bioenergy with CCS (BECCS) deployment in SSP2-RCP26 (160 EJ/yr in 2050, 255 EJ/yr in 2100) (see Kato and Yamagata 2014). Half of bioenergy supply is used for BECCS in 2100 driven by the need for negative emissions. The current study focusses on the land use requirements needed for realizing this high amount of bioenergy. The most controversial and influential assumptions

relate to the future role of energy crops. Yields of lignocellulosic bioenergy crops were simulated with a spatially explicit land use model. Huge biomass potential exists in cases of mid and high fertilizer application. High application leads to doubling of yields. Second generation bioenergy crops can fulfill the required BECCS only with high-fertilization and high carbon capture. At least 72% of carbon needs to be sequestered. Doubling the yields requires the bioenergy cropland to expand by 450 million ha and the nitrogen fertilizer application to increase by 77%. LUC emissions by cropland expansion are highly uncertain, however, non-negligible (80 ± 34 Pg C for 2005-2100). Fertilizer requirements 73 Tg N / year in 2100. This may be in conflict with planetary boundaries. Therefore, additional N2O emissions need to be minimized. In summary, large improvements in agricultural and ecological management of bioenergy crops are required for ambitious climate mitigation. Sustainability criteria for land, fertilizer, and water are important but might limit BECCS.
In the Q&A session Etsushi Kato was asked about plans to include nutrients. For the time being phosphorus limitation is not considered.

Large-scale bioenergy production: Can adjustment policies neutralize negative side effects?
Florian Humpenoeder (PIK) discussed whether adjustment policies can neutralize negative side effects of large-scale bioenergy production such as CO2 emission from deforestation and fertilizer application, water use, competition with food production (rising food prices). Using the spatial explicit land use model MAgPIE nine different adjustment policies related to bioenergy production and their effect on the following sustainability indicators are evaluated: land-use change and associated CO2 emissions, nitrogen fertilizer use, agricultural water withdrawals, and development of food prices. The adjustment policies are mainly increased bioenergy crop yields; higher nitrogen efficiency; no irrigation for bioenergy crops; forest protection; and pricing LUC emissions. The policies show clear positive effects on their target sustainability indicator:
Land-use change emissions from bioenergy production are substantially alleviated if bioenergy yields are increased, and even neutralized if LUC emissions are priced. Increasing the bioenergy crop yields and the fertilizer efficiency substantially reduce the nitrous oxide emissions from bioenergy production. Water withdrawals decrease with increasing bioenergy crop yields and drop to zero if bioenergy is not irrigated.
However, there are also trade-offs between the policies: not irrigating bioenergy comes at the cost of substantial cropland expansion (mainly into forests) to compensate for lower crop yields and thus increases LUC emissions. Pricing LUC emissions stops LUC emissions from bioenergy crop production but increases food prices.
Finally, our scenarios show that combining the most effective adjustment policies substantially alleviates adverse side effects of bioenergy production in multiple sustainability dimensions at the same time including food prices.
In the Q&A session Florian Humpenoeder clarified that food demand is exogenous and consumers are price takers. He specified that costs of different policies are included in the model. Also, leakage is included in the CO2-price scenarios, because only emissions from deforestation are priced, there is leakage by land expansion into "other land".

Prospects and challenges concerning carbon dioxide removal from the atmosphere by biomass-based capture and storage in Brazil
Alexander Köberle (COPPE) presented prospects and challenges concerning carbon dioxide removal from the atmosphere by biomass-based capture and storage in Brazil. Most models show Brazil reducing emissions significantly in mitigation scenarios. In the applied Message-

Brazil model emissions are constraint to 1 Gt CO2eq total emissions in 2030-2050 (that is 15% lower than Brazil's current INDC of 1.2 Gt). The results show significant BioCCS starting already in 2020 mostly capturing from pure CO2 stream of ethanol distilleries (cheap to capture, model picks this). The maximum possible reduction is -30% in 2030 compared to 2010. The model deploys BECCS to generate negative emissions resulting in excess production of ethanol that would have to be exported. Therefore additional technologies were implemented: ethanol busses and trucks, and stationary ethanol electricity generation (can be used to firm intermittent renewable energies). Production side: for fuel production CCS technologies step in by 2020 and 2030 at the latest (>94% with CCS), mainly Fischer-Tropsch and biochemical hydrolysis. For electricity production BioH2 with CCS is applied (>112 TWh in 2050, 100% CCS). Demand side: flex vehicles dominate private passenger modal, mostly driven on the excess ethanol in mitigation scenarios. In Scenario 2, the public terrestrial transportation modal is taken over by ethanol buses starting in 2030, accounting for 100% of all terrestrial public transport by 2050. A case study was presented firming wind power in the North-East of Brazil (Rio Grande do Norte). There is a crisis in distillery sector. At the moment the annual capacity factor in the EtOH sector is very low at 7%. Combining EtOH-electricity with intermittent renewables could significantly increase the capacity factor up to 22%. There are 2 GW of wind capacity in this areas. The low wind in summer complements peak in harvesting season. However, LCOE is very high (around 0.24 ct/kWh). Potential uses of captured CO2 in Brazil are markets, oil drilling (CO2 injection), methanol production, urea production. However, storage is full of challenges, e.g. public opposition. Future plans are to consider LU impacts with the PLUC model and to develop a Latin America Energy Model extending from Brazil.
In the Q&A session, the question was raised if IAMs are too optimistic about biomass gasification. The technology is very fuel specific; engineers have problems to get it going. Gasification of biomass is enormous challenge.
Also, the audience asked Alexander Köberle how he deals with different economies of scale of many small, scattered CO2 production sites and the CO2 pipeline network. Alexander Köberle explained that he looked at the pipeline network to capture CO2 and that there is feasibility because in some areas plants are concentrated in specific locations (State of Sao Paulo).
The audience asked if we are too optimistic about CCS availability. Mr. Köberle pointed out that there is no institutional framework for CCS in Brazil. Negative emissions would need to start in 2020 if other sectors do not deliver (scenario result).

CLOSING PLENARY

Report from the scenarios scientific working group

Tom Kram (PBL) pointed out that the work of the scenarios scientific working group is a community effort. The SWG acts on behalf of the IAMC to 1) co-ordinate the development of new community scenarios within the IAMC and 2) to co-ordinate the communication and exchange with the other two scientific communities on issues related to community scenarios (CM/ESM and IAV). Upcoming activities of the SWG include: cooperation with ICONICS (International Committee On New Integrated Climate change assessment Scenarios) including regional workshops on Africa and India, the delivery of climate information to other research groups and the drafting of a high-impact paper on the scenario process. It was pointed out that it would be important to bring more IAMs into the process and investigate how to couple regional and global scenario processes. This was followed up in the next presentation by Volker Krey, and during the SWG session on Wednesday.

Report from the data protocols and management scientific working group

Volker Krey (IIASA) introduced a proposal, jointly developed by the SWGs on scenario and data protocol and management, to establish a community scenario repository to include more IAMs into the SSP process. It was noted that the example of the AR5 scenario database which is heavily used for scenario analysis and cited in scientific and policy reports shows that demand for this type of community resource exists. Important discussion points included whether (i) a distinction between fully harmonized scenarios that utilize the quantitative socio-economic projections developed in the SSP process and scenarios that follow the storyline of the SSPs is useful, (ii) minimum criteria for submission to such a repository should be established (e.g., sector coverage, time horizon, publication) and (iii) extended quality controls are needed for scenario repository. Further discussions on the establishment of a committee or subgroup that will develop a process for establishing a community scenario repository and look into more detailed issues were held as part of the SWG meetings on day 3.

Related to the SSP process is the need for downscaling information, in particular emissions of short-lived species, to the grid level for feeding into atmospheric chemistry and climate models as part of CMIP6. PNNL (Steve Smith) within the CEDS project is in the process of putting an inventory of historical emissions up to 2014 together, including downscaling emissions to 0.1*0.1 degrees. Given that infrastructure and tools are being developed for downscaling of historical emissions, Steve also offers using these for downscaling of emissions from SSP-based scenarios which implies adopting a centralized process, i.e. using one method for all SSPs. Another topic of the SWG is the better harmonization of region definitions across IAMs. The main idea is to identify a standard set of regions that can be mapped onto IAM regions.

Finally, on model documentation, there is an ongoing activity for developing harmonized IAM documentation under the ADVANCE project (Wiki hosted by UCL). Reference cards and a 30-page harmonized model documentation were produced for 10 models. The documentation was subject to public review comments, but only a few comments were received. The comments focused on (i) improving documentation of model parametrization which is currently only covered to a limited degree, (ii) allowing for an easier comparison of documentation across different models, as well as (iii) a stronger standardization of documentations by developing templates for different types of models (e.g., CGEs, energy systems based models) to avoid using a one size fits all approach.

In the discussion, PIK asked about the timeline of an Open Source tool for spatial downscaling, as PIK is currently developing a framework. It would be useful to create community resources for data management. The further discussion focused on establishing a process for reviewing scenario submissions to the envisioned community scenario repository that were continued in the SWG sessions on Wednesday (see below).

Report from the evaluation and diagnostics scientific working group

Jae Edmonds (PNNL) recalled the objective of the SWG to facilitate attention to model evaluation and diagnostics in the community, pointing out that the process of model evaluation is multi-faceted, including documentation, diagnostics, and hindcasting. He then reported on progress, particularly in the ADVANCE and PIAMDDI projects. The EU-funded project ADVANCE organised an open community diagnostics exercise consisting of numerical experiments designed to diagnose and characterize response patterns of models to carbon pricing. The activity is still open. The available infrastructure includes a database with automatic calculation of indicators and automated climate response. The DOE-funded project PIAMDDI followed a different approach: model validation is based on hindcasting of model components. The question was brought up that hindcasting is data intensive, but data sharing

would be welcome. It would be important to have further discussions on how to intensify cooperation on this.

Overview of ongoing community activities

Progress on the following community activities was presented:

- CD-LINKS - Linking Climate and Development Policies - Leveraging International Networks and Knowledge Sharing
- GTAP - Climate Change and Economic Growth: Impacts and Interactions
- AVOID climate change research programme
- Scientific Priority Programme on Climate Engineering of the German Research Foundation
- MILES - Modelling and Informing Low Emission Strategies
- ADVANCE – Advances Model Development and Validation for the Improved Analysis of Costs and Impacts of Mitigation Policies
- BRACE - Benefits of Reduced Anthropogenic Climate Change
- ISI-MIP Energy - The Inter-Sectoral Impact Model Intercomparison Project
- EMF 30: Short Lived Climate Forcers / Air Quality
- EMF 31: North American Natural Gas and Energy Markets in Transition
- EMF 32: US GHG and Revenue Recycling Scenarios
- EMF 33: Bio-Energy and Land Use

THE FUTURE OF IA MODELLING

Evaluating model analysis of climate change mitigation

Charlie Wilson (UEA) discussed the topic of how to evaluate integrated assessment models. There are two main categories: structural validity (accurate representation of the system) and behavioural validity (consistent with observational data). IAM validity would have to rest on the former, which by its very nature cannot be proven completely, because the systems are so complex that there is irreducible uncertainty, and because the models describe future scenarios, which inherently cannot be observed ex ante. He explored different evaluation criteria, and compared how the IAM and GCM communities prioritize and address the different criteria. He called for more systematic and more prominently published IAM evaluation to help strengthen and maintain confidence in IAMs.

Panel of researchers providing perspectives on challenges and directions for IA

In the panel discussion, **Ottmar Edenhofer (PIK)** started by pointing out that many mainstream economists claim “we do not need IAMs”, but that their proposed methods (econometrics, laboratory experiments) are not suited to develop the long-term transformation strategies needed to address climate change. The IAM community should work on improving the interface to mainstream economists so that the relevance of integrated assessment modeling is better appreciated in the scientific world. He also called for a focus on improving how IAMs represent structural change and uncertainty, inequality, and the macro-economics of climate change impacts mitigation in general, including topics like international trade, liquidity constraints, or the financial sector.

In the discussion round, participants stressed that there is a trend to go into “micro-foundation research”, which focuses only on the local and personal context. IAM modeling needs to stem

the tide, because micro-foundation research usually misses the larger links and the aggregated picture, and therefore is limited in its capability to deal with large-scale transformation questions. Also, participants recognized that there is no need to develop each individual model in order to include everything, but a need to set-up platforms that allow different modelling teams to come together and engage in joint analyses.

Evelina Trutnevyte (ETH Zürich) discussed socio-technological transitions and the "sustainability transitions research network" (STRN). This approach focuses on how technologies and societal structures develop and coevolve, and how transitions between different states happen. This community has produced many conceptual studies, but only few applied studies exist. A promising future development would be to build on existing models, but use the knowledge of transition scholars to develop governance storylines.

Gregory Nemet (U Wisconsis) presented thoughts on characterizing long-term technological change. Presenting expert elicitations for PV, he showed how actual PV prices dropped much faster than expected by experts. Still, he disagrees with researchers claiming that nothing of value can be said about future technological change, and rather calls for a detailed analysis of past technology evolution to distill the main stylized facts and underlying patterns.

Bas van Ruijven (NCAR) discussed how to enhance the relevance of the SSPs for the impacts, adaptation and vulnerability community. This community requires additional indicators that are currently not contained in the main SSP definitions. Indicators that could raise the usefulness of SSPs would be income distribution, spatial population projections, governance indicators, as well as indicators on human health. . Some of these indicators can be produced by IAMs, while other could be derived from other scientific disciplines.

IAMC business and closing remarks

The IAMC meeting was concluded with the announcement of best poster awards to Oliver Fricko (IIASA; work on water-energy nexus) and Jessica Strefler (PIK; work on the role of enhanced weathering for climate mitigation), and the IAMC Annual Award 2014 for outstanding achievements in the field of integrated assessment to Leon Clarke (PNNL).

DAY 3: WEDNESDAY, NOVEMBER 18, 2015

SCIENTIFIC WORKING GROUP MEETINGS

Scenarios SWG

In an introductory talk, **Keywan Riahi (IIASA)** presented the current status of the working group. It coordinates three main activities: (i) the finalization of the SSP IAM marker scenario development, (ii) the facilitation of widespread use of IAMs in the SSP framework, (iii) providing a contact point for ScenarioMIP and the coordination of the preparation of required input for the Earth System Models. The session centred around the second activity with a focus on the database of IAM scenarios in the SSP framework to be established.

A first open question is which IAM scenarios should be included. The database should be open not only to other global models, but also to regional, national and sectoral models running

SSPs. Additionally there should be a distinction between harmonized (i.e. following certain standards for the interpretation of a given SSP, notably on population and GDP) and non-harmonized (own interpretations) scenarios, starting from the SSP Narratives or other interpretations of the matrix. A working group within the SWG is needed to develop guidelines, to establish the database itself – working with the Data protocols and management SWG, manage submissions and quality control. The guidelines would include the SSP storylines, the GDP and population projections, qualitative guidance on key IAM assumptions (energy technologies, demand, resources, land-use change) and the Shared Policy Assumptions. These guidance materials should be completed by February 2016, the database development will take place between January and April/May, to open the database around the time of the publication of the SSP Special Issue. A review process for submissions to the database will be established. Any IAMC member interested to participate in this process is very welcome and should contact Tom Kram, Keywan Riahi or Detlef van Vuuren.
The discussion centred on the purpose of the database and the incentive of modelling teams to submit to it, the extent of a quality control and the organization of scenarios. There was broad consensus that the database should be open to whole community and encourage a large variety of submissions. Scenarios should be categorized e.g. as a replication of the marker SSPs, something just implementing certain aspects (e.g. the population/GDP scenarios) or own interpretations/new SSP developments. Quality control should focus mainly on the existence of an appropriate documentation (e.g. a publication, filling in the Advance Wiki) and on possible obvious errors like discontinuities in the data. Some of this can be automated but a review committee will also be necessary. A variety of incentives to submit to the database were discussed, including the design of activities like EMF rounds to contribute to the database, the comparison of own data with others, the dissemination of own data for use by others (including e.g. the IAV community), the use of tools developed to accompany the database (e.g. downscaling tools) or direct credit for scenarios used in publications (instead of blanket citations). It was also proposed to move step-by-step, starting smaller and seeing how the database will be received by the broader community, before designing a too elaborate process, as this will require large (voluntary) resources.

Data protocols and management SWG

The session of the working group on data protocols and management was split into two parts. First **David McCollum (IIASA)** presented work by the subgroup on harmonizing regional information in IAMs. This activity explores option for further harmonization of regions which would improve the comparability of regional model output and input and also help to better harmonize regionally fragmented polices across models. The subgroup proposes a hierarchical concept with three levels of benchmark regions. A high-resolution level of e.g. 30 regions maps to the native regional resolution of models (around 12 regions) which then maps to a top level low resolution set of around 5 regions. A detailed proposal is made starting with the 5 SSP regions and breaking them up via various levels. No sub-national detail is included at this point. This proposal is now ready for review and vetting by the community, in particular modeling teams from each large region should vet in detail the proposed break-up hierarchy for their region.
A number of important points were brought up in the discussion. It was pointed out that a number of national modeling groups (e.g. his own from Brazil but also groups from India and China) are now getting ready to expand their models globally. At this point they are still very flexible with their regional resolution, so if a timely decision on the proposal was made, they could implement that directly. One of the participants missed a national level below the

current highest resolution level, as there can already be model-specific differences on which countries are part of these smaller regions. It was also suggested to make some important countries that are difficult to assign to larger regions simply own regions, the most prominent example being Turkey. Finally the criteria for the setup were discussed. They include area, GDP, population (i.e. largely what makes sense from an emissions point of view) but should also address e.g. the point of view of land-use models, the relevance for a variety of users (e.g. UN, Worldbank) and the changes required from each working group should be minimized. It was suggested to map this proposal to the current regional resolution of models to assess the amount of necessary changes. It was also pointed out that the idea of benchmark regions is not that everybody has to adopt these regions but they provide benchmarks for harmonization and mapping of input and output data.

The second part of the session focused on the work on harmonized model documentation. **Volker Krey (IIASA)** presented the publicly available ADVANCE Wiki as a starting point. It includes two levels of detail: reference cards (tables with predefined categories as a quick model overview) and a moderated Wiki with more detailed information (length equivalent to 30 pages of print). Open questions include a possible revision of the current structure with some refinement for enhanced comparability (e.g. more refined templates), other formats aside from a Wiki, central vs. self-hosting the documentation, linking the documentation to parametric assumptions (as, e.g., collected under the ADVANCE diagnostics exercise).
In the discussion it was pointed out that while this is an important overview over main characteristics of the models, it does not take the place of a very detailed model documentation which should be pointed out to users. This is in line with what stakeholders indicated as their needs in a consultation process before establishment of the ADVANCE Wiki. Regarding more detailed templates, it was suggested to identify teams using different types of models to provide a good-practice example instead of trying to generate generic templates. For the review process it was proposed to have a volunteer who would find an appropriate modeling team to review each incoming new model documentation, to share the work load. Finally a link to the scenario database was suggested for scenario-based parametric documentation.

Evaluations and diagnostics SWG
In the introduction **Jae Edmonds (PNNL)** pointed out that model comparison, diagnostics and hindcasting are part of a larger process of model validation.
Elmar Kriegler (PIK) reported in his presentation on evaluation and diagnostics (E&D) experiences from the ADVANCE project. He highlighted that it would be great to have E&D standards similar to those of the GCM community. He outlined the diagnostic experiments done in ADVANCE (multiple tax scenarios run by 15 different models) and the existing diagnostic infrastructure which includes the automatic generation of diagnostic indicators. He also mentioned the major efforts that were made regarding the reporting on input assumptions and the future plans for extending the diagnostics analysis to capture also sectoral and regional response to carbon pricing. Of particular interest are also shock scenarios that help to identify inertia properties of IA models. Elmar Kriegler finally pointed out that the diagnostic database is open for submission, while it cannot be guaranteed that new submissions can already be included in the current analysis.
In the discussion, participants confirmed the relevance of looking into carbon price responses, which for example allows identifying bottlenecks in the transport sector. They acknowledged the fingerprints provided by the diagnostic analysis, but raised the question, how the

reasonability of model outcome can be tested more specifically. Elmar Kriegler suggested adopting a method used by GCMs: classify models according to the domains they are good for. The question was raised on what can be learned from the diagnostics ("What next?"). Can we decide who is right and who is wrong based on diagnostics? Can we go beyond identifying outliers? Elmar Kriegler replied that this would require additional evaluation approaches such as historical pattern testing, but diagnostics should help to explain why models behave the way they do and also help to classify their behaviour. One of the participants mentioned a complication to next steps in E&D, which is the missing yardstick (the future is inherently uncertain - example of population in Syria). However, it might be possible to illustrate model inertia and the relation of model behavior to historical events. Other participants were rather sceptical regarding historical tests, but recognized the usefulness of diagnostic fingerprinting for, e.g., the discussion on 1.5°C stabilization, as only fast reacting, high response models are likely to meet this stabilization target.

In the second part **John Weyant (U Stanford)** presented PIAMDDI (Program on Integrated Assessment Model Development and Inter-Comparison). This program focuses on US IAMs (GCAM, EPPA model, MERGE). John Weyant mentioned the communication with climate diagnostic teams as part of the program. He outlined the basic method, tracing back different model results to different model behavior, and the possible synergies of a broader use of new methods developed under this program. He also discussed the evaluation of different tax scenarios and cost studies (wrt carbon intensity, electricity production by technology, solar penetration) and highlights the estimation of price elasticities of CO2 that can be of use for other models.
In the discussion the question was raised whether PIAMDDI can be combined with ADVANCE/AMPERE diagnostics. John Weyant answered that AMPERE indicators were used in the past, a paper is about that. It was pointed out that comparability of different comparison studies and E&D exercises is difficult and that a comparable protocol and diagnostic indicators would be helpful. The question was raised on how community standards can be provided. John Weyant affirmed the possibility and willingness of PIAMDDI to use diagnostic indicators of ADVANCE/AMPERE, and also the already existing implementation. One of the participants highlighted the importance of exchange with other MIPs (e.g. AgMIP). John Weyant referred to a joined comparison study with the AgMIP group. Another participant raised the question on how others (outside this group) could be motivated to do E&D work. It was replied that a combination of PIAMDDI and ADVANCE/AMPERE increases credibility of IAMs and enforces a standard that possibly will generate followers.
Finally, Jae Edmonds invited all to send new ideas of E&D to Elmar Kriegler, John Weyant and Jae Edmonds.

As the last topic of the session, **Charlie Wilson (UEA)** provided his feedback on model validation, which due to a shortage of time happened to be in a very compact form. He first highlighted that the argumentation that model validation based on replication of historical data is not possible for IAMs does not hold, at least with reference to missing data. He, second, pointed out that additional data is available. There are observational data on climate policy for 20 years and empirical data on shock events (oil crises, collapse of FSU) for 30-40 years. He third encouraged the community to establish a standardized MIP structure, and fourth, pointed out that the community to be included into E&D efforts should be broadened. He finally addressed the issue of publication. While he sees MIPs and sensitivity analyses, in general, well published, he recognizes that the technical details of diagnostics are not

prominently published (only hidden in technical papers). The production of synthesis papers would be helpful.

The presentations and discussion were well received and several discussants expressed their wish to keep the sequential format of working group sessions also in future IAMC meetings.

ANNEX I: AGENDA

Agenda for the 8th Annual IAMC Conference

hosted by the Potsdam Institute for Climate Impact Research and held at the Seminaris Seehotel, Potsdam, Germany

Sunday, November 15, 2015			
18:00		Informal Opening Reception	

Day 1: Monday, November 16, 2015			
Opening Plenary (Plenary Room III)			
08:30	08:45	Welcome and introductory remarks	Ottmar Edenhofer, PIK
08:45	09:00	Introduction to the meeting	John Weyant, U Stanford & EMF
The road to Paris and beyond – Where do we stand on INDCs, what is the future role for the community in assessing INDCs?			
09:00	09:20	Implementing the Paris outcome (agreement, decisions, INDCs, Lima-Paris Action agenda) for realising the global transition to a low-emission climate-resilient economy (incl. Q&A)	Miles Perry, DG Climate Action, European Commission
09:20	09:40	The INDC assessment of the UNEP Emissions Gap Report 2015 (incl. Q&A)	Michel den Elzen, PBL
09:40	10:00	Implications of the INDCs for reaching long term climate policy objectives (incl. Q&A)	Christoph Bertram & Gunnar Luderer, PIK
10:00	10:30	Panel of modellers / policy makers from major emitting countries (~5x6 min inputs): *How useful and relevant was the work of the IAM community for the Paris negotiations, and what insights are sought from the IAM community for the post-Paris process?*	Allen Fawcett (EPA, US), Jiang Kejun (ERI, China), Miles Perry (DG Climate Action, EC), Toshihiko Masui (NIES, Japan), Ritu Mathur (TERI, India), Roberto Schaeffer (COPPE, Brazil)
10:30	11:00	Discussion between audience and panel	
11:00	**11:30**	**Break**	
How to use the new climate change (SSP-RCP) scenarios in future IAM, IAV and climate modelling studies?			
11:30	11:45	Overview and status of the SSP scenario process	Detlef van Vuuren, PBL
11:45	11:55	scenarioMIP and other CMIP6 activities	Brian O'Neill, NCAR
11:55	12:05	Q&A	
12:05	12:25	AgMIP and ISI-MIP perspective (incl. Q&A)	Hermann Lotze-Campen, PIK
12:25	12:40	Results of the IPCC scenario meeting and future scenario process	Keywan Riahi, IIASA
12:40	13:00	Discussion on ways for IA community to contribute to scenario process	

13:00	**14:00**	**Lunch**

Day 1: Monday, November 16, 2015

Parallel Session: Analysis of climate change and climate impacts in IAM applications (Plenary Room III)

14:00	14:05	Introduction	Tom Kram (PBL), Kate Calvin (PNNL), Juan-Carlos Ciscar (JRC-IPTS)
14:05	14:30	Searching for the weak spot– A comprehensive investigation of climate change impacts and macroeconomic growth	Franziska Piontek, PIK
14:30	14:55	Economic impacts of climate change on human health through undernourishment	Tomoko Hasegawa, KRISH/NIES
14:55	15:20	Avoiding the impacts of climate change: Results from the BRACE study	Brian O'Neill, NCAR
15:20	15:45	On the consequences of constraining water to energy and land use	Mohamed Hejazi, PNNL
15:45	**16:15**	**Break**	
16:15	16:35	Confronting and reducing future risks in Water-Energy-Land Systems	Adam Schlosser, MIT
16:35	16:55	Interactions between Climate Change Mitigation and Adaptation in Energy Scenarios for Brazi	André Lucena, PPE/COPPE/UFRU
16:55	17:15	The economic consequences of climate change to 2060	Rob Dellink, OECD
17:15	17:35	Estimating Global Damages from Sea Level Rise with the Coastal Impact and Adaptation Model (CIAM)	Delavane Diaz, EPRI
17:35	18:00	Moderated discussion	Tom Kram, PBL

Parallel Session: Uncertainty and the use of IAM projections (Plenary Room II)

14:00	14:05	Introduction	John Weyant (U Stanford), Leon Clarke (PNNL), Steve Rose (EPRI)
14:05	14:25	Modelling to generate alternatives: A technique to explore uncertainty in integrated assessment models	James Price, UCL
14:25	14:45	A methodology to investigate the uncertainty of scenario drivers and the diversity of socio-economic pathways with similar outcomes	Celine Guivarch, CIRED
14:45	15:05	Climate policy under socio-economic scenario uncertainty	Johannes Emmerling, FEEM
15:05	15:25	UK electricity system modeling 1990-2014 and the (im)possible mission of embracing parametric and structural uncertainties	Evelina Trutnevyte, ETH Zürich
15:25	15:45	Climate policy as risk management	Geoffrey Blanford, EPRI
15:45	**16:15**	**Break**	
16:15	16:35	Next steps in uncertainty analysis for the IAM community: Lessons from the IPCC scenarios database	Bas van Ruijven, NCAR
16:35	16:55	Exploring the feasibility of low-carbon scenarios using historical energy transitions analysis	Ajay Gambhir, Imperial College London
16:55	17:15	Global energy model hindcasting and validation	Shinichiro Fujimori, NIES
17:15	17:35	Comparing future patterns of energy system change in 2°C scenarios with historically observed rates of change	Mariesse van Sluisveld, PBL
17:35	18:00	Moderated discussion	John Weyant (U Stanford), Leon Clarke (PNNL)

18:00	**18:30**	**Break**

Poster Session with buffet dinner
See Annex 1 for Poster IDs, Titles and Presenters

17:35 19:30 Slot 1

Thematic areas: 1. Analysis of climate change and climate impacts in IAM applications; 2. New IAM analyses on the climate policy – sustainable development nexus, 3. Analyses of distributional impacts of mitigation pathways and/or climate change, 4. Uncertainty and the use of IAM projections, 5. Modeling Tools

19:30 20:30 Slot 2

Thematic areas: 6. Integrated assessment of INDC proposals and their implications for global emissions, 7. Integration of variable renewable energy, 8. Transport modeling, 9. Fossil fuel resources and technologies, 10. Analyses of the low carbon transformation, 11. Integrated assessment of climate engineering and carbon dioxide removal technologies

Day 2: Tuesday, November 17, 2015

Parallel Session: From climate policy to broader sustainable development analysis: New IAM analyses on the climate policy – sustainable development nexus (Plenary Room III)			
08:30	08:35	Introduction	Keywan Riahi (IIASA), Bas van Ruijven (NCAR), Detlef van Vuuren (PBL)
08:35	08:55	Pathways to achieve a set of ambitious global sustainability objectives by 2050: Explorations using the IMAGE integrated assessment model	Detlef van Vuuren, PBL
08:55	09:15	Using the International Futures Model to enhance the socioeconomic representation of the Shared Socioeconomic Pathways (SSPs) for understanding challenges to adaptation	Dale Rothman, U Denver
09:15	09:35	Can Paris deal boost SDGs achievement? An assesment of climate-sustainabilty co-benefits	Lorenza Campagnolo, FEEM
09:35	09:55	Environmental impacts of alternative power sector decarbonization strategies	Gunnar Luderer, PIK
09:55	10:15	Will climate mitigation policies affect the energy poor? Synergies and tradeoffs between climate mitigation and universal clean cooking access goals	Kevin Ummel, IIASA
10:15	**10:45**	**Break**	
10:45	11:05	Modeling the energy-water-food nexus: A review of the opportunities and challenges for integrated assessment modeling	Nils Johnson, IIASA
11:05	11:25	Water demand for energy and food: a nexus analysis based on the Shared Socioeconomic Pathways	Ioanna Mouratiadou, PIK
11:25	11:45	Economic impacts of the land-water-energy nexus	Fritz Hellmann, PBL
11:45	12:05	Evaluating the impact of climate policies on regional food accessibility using an Integrated Assessment Model	Elisabeth Gilmore (U Maryland), Stephanie Waldhoff (PNNL)
12:05	12:30	Moderated discussion	Keywan Riahi (IIASA), Bas van Ruijven (NCAR), Detlef van Vuuren (PBL)

Parallel Session: Integrated assessment of climate engineering and carbon dioxide removal technologies (Plenary Room II)			
08:30	08:35	Introduction	Elmar Kriegler (PIK), Massimo Tavoni (FEEM)
08:35	09:05	The potential and limits of solar geoengineering and the trade-offs involved in substituting it for mitigation	Pete Irvine, IASS
09:05	09:30	Geoengineering and climate agreements: a numerical assessment of the regional strategic incentives	Massimo Tavoni, FEEM
09:30	09:55	The role of carbon dioxide removal technologies for achieving long-term climate policy objectives: an analysis of the larger portfolio of CDR options	Jessica Strefler, PIK
09:55	10:20	Is Direct Atmospheric Capture the needed backstop technology for decarbonizing the global energy system or does it just complement BECCS?	Evangelos Panos, PSI
10:20	**10:50**	**Break**	
10:50	11:15	Sustainable land-use scenario toward negative emissions pathways	Etsushi Kato, IAE
11:15	11:40	Large-scale bioenergy production: Can adjustment policies neutralize negative side effects?	Florian Humpenöder, PIK
11:40	12:05	Prospects and challenges concerning carbon dioxide removal from the atmosphere by biomass-based capture and storage in Brazil	Alexander Köberle, COPPE
12:05	12:30	Moderated discussion	Elmar Kriegler (PIK), Massimo Tavoni (FEEM)

12:30	**13:30**	**Lunch**	

Day 2: Tuesday, November 17, 2015

Closing Plenary (Plenary Room III)			
13:30	13:45	Report from the scenarios scientific working group (incl. Q&A)	Tom Kram (PBL), Keywan Riahi (IIASA), Detlef van Vuuren (PBL)
13:45	14:10	Report from the data protocols scientific working group (incl. Q&A)	Volker Krey, IIASA
14:10	14:25	Report from the evaluation and diagnostics scientific working group (incl. Q&A)	Jae Edmonds, PNNL
14:25	14:45	Overview on community activities	
14:45	**15:15**	**Break**	
The Future of IA Modeling			
15:15	15:40	The evolving role of IA and emerging critiques (incl. Q&A)	John Weyant, U Stanford
15:40	16:05	Evaluating model analysis of climate change mitigation (incl. Q&A)	Charlie Wilson, UEA
16:05	16:45	Panel of researchers providing perspectives on challenges and directions for IA (~4 x 10 min inputs)	Ottmar Edenhofer (PIK), Evelyna Trutnevyte (ETH Zürich), Gregory Nemet (U Wisconsin), Bas van Ruijven (NCAR)
16:45	17:15	Open discussion of IA priority areas, strategy and criticism	
17:15	17:30	Other IAMC business and closing remarks	

Day 3: Wednesday, November 18, 2015

Scientific Working Group Meetings			
09:00	10:00	Scenarios SWG	Tom Kram (PBL), Keywan Riahi (IIASA), Detlef van Vuuren (PBL)
10:00	**10:30**	**Break**	
10:30	11:30	Data protocols and management SWG	Volker Krey & David McCollum (IIASA)
11:30	12:30	Evaluations and diagnostics SWG	Jae Edmonds (PNNL), Elmar Kriegler (PIK), John Weyant (U Stanford)

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ANNEX III: POSTERS PRESENTED AT POSTER SESSION ON NOVEMBER 16

Posters are available via the IAMC website at:
http://www.globalchange.umd.edu/iamc/events/eighth-annual-meeting-of-the-iamc/

Poster Session - Slot 1
November 16, 2015

Poster Session with buffet dinner **18:30-19:30 Poster Session Slot 1**		**Chairs:** Volker Krey (IIASA), Gunnar Luderer (PIK), Roberto Schaeffer (COPPE), Narasimha Rao (IIASA), Bas van Ruijven (NCAR)
ID	**Title**	**Presenter**
1. Analysis of climate change and climate impacts in IAM applications		
1.1.	Global economic impacts caused by space heating and cooling demand changes	Shinichiro Fujimori, NIES
1.2.	A consistent and comprehensive analysis of climate change impacts on the energy system – A status report on ISI-MIP ENERGY	Franziska Piontek, PIK
1.3.	Linking human and earth system models to assess regional impacts and adaption	Brian O'Neill, NCAR
1.4.	Energy sector adaptation in response to water scarcity	Oliver Fricko, IIASA
2. New IAM analyses on the climate policy – sustainable development nexus		
2.1.	Spanning the inequity simplex across time, states and regions	Loic Berger, FEEM
2.2.	Potential land-use futures: applying different indicators to assess the endogenous trade-offs between cropland land expansion and intensification	Xiaoxi Wang, PIK
2.3.	Land use emissions abatement and consequences for food prices	Miodrag Stevanovic, PIK
2.4.	Modelling efficient and equitable scenarios for a stringent carbon constrained world with the IEA-ETSAP's Integrated Assessment Model; TIAM-MACRO	James Glynn, U College Cork
2.5.	Assessing the global co-benefits and risks of alternative 2°C pathways	Christoph von Stechow, MCC
2.6.	Exploring synergies between climate and air quality policies	Maarten van den Berg, PBL
3. Analyses of distributional impacts of mitigation pathways and/or climate change		
3.1.	Development perspectives of Sub-Saharan-Africa under climate policiess	Marian Leimbach, PIK
3.2.	Impacts from climate change and climate policy on urban and rural households	Bas van Ruijven, NCAR
3.3.	Synergies and Trade-offs between Climate Mitigation and Universal Access to Clean Cooking Goals	Narasimha D. Rao, IIASA
4. Uncertainty and the use of IAM projections		
4.1.	Uncertainty in IA Model estimates: the impact of real-world barriers to technology adoption	Matteo Muratoni, PNNL
4.2.	Mitigation costs and uncertainty	Laurent Drouet, FEEM
4.3.	Uncertainty in land resource projection associated with static geographic land units in an integrated assessment model	Alan Di Vittorio, LBL
4.4.	Global warming and a potential tipping point in the Atlantic thermohaline circulation: The role of risk aversion	Mariia Belaia, U Hamburg
4.5.	An hybridization of system dynamics and agent based models to predict scenarios and interprete IAM projections - intelligent adaptive coupling OR analytic simulations and	Stefan Pickl, Bunderswehr Universität München
5. Modeling tools		
5.1.	Baseline energy demand projections for Integrated Assessment Modeling	Antoine Levesque, PIK
5.2.	Harmonized preparation of model inputs for flexibility in regional model composition	Lavinia Baumstark, PIK

Poster Session - Slot 2
November 16, 2015

Poster Session with buffet dinner **19:30-20:30 Poster Session Slot 2**		**Chairs:** Volker Krey (IIASA), Gunnar Luderer (PIK), Roberto Schaeffer (COPPE), Narasimha Rao (IIASA), Bas van Ruijven (NCAR)
ID	**Title**	**Presenter**
6. Integrated assessment of INDC proposals and their implications for global emissions		
6.1.	Which emissions and temperature pathways could the Paris pledges lead to? What climate impacts would these pathways avoid?	Ajay Gambhir, Imperial College
6.2.	Integrated assessment of the effect of current policies, pre-2020 pledges and INDCs on global emissions	Detlef van Vuuren, PBL
6.3.	Understanding the global implications of INDCs for the 2°C target	Christoph Bertram, PIK
6.4.	Comparative assessment of the regional economic impact of selected INDCs for real-time policy advice using existing IAM scenarios	Ryan Alexander, PIK
6.5.	Evaluations on the Japan's INDC in comparison with other nations', and in the context of achieving 2°C target	Fuminori Sano, RITE
6.6.	On incompatibility of energy policy and climate policy: South Korea Case	Sung Won Kang, KEI
6.7.	Energy-economic models and policymaking: International comparison	Masahiro Sugiyama, U Tokyo
7. Integration of variable renewable energy		
7.1.	Improving the variable renewable energy technology representation in integrated assessment models	Yvonne Scholz, DLR
7.2.	How a very detailed representation of energy efficiency options in the objective-function of MESSAGE-Brazil can affect penetration of VRE in the Brazilian power grid	Roberto Schaeffer, COPPE
7.3.	Improving the representation of wind and solar variability in Integrated Assessment Models	Robert Pietzcker, PIK
8. Transport modeling		
8.1.	The transportation sector as a lever for reducing long-term mitigation costs in China	Meriem Hamdi-Cherif, CIRED
8.2.	Emission reduction potential of carbon taxes on international transportation	Yong Gun KIM, KEI
8.3.	Incorporating social influence effects into global transportation models	Hazel Pettifor, U East Anglia
8.4.	Reduced form representation of the transport sector: a model comparison study	Oreane Edelenbosch, PBL
8.5.	Exploring the role of transport infrastructure in a low-carbon world	Eoin Ó Broin, CIRED
9. Fossil fuel resources and technologies		
9.1.	The role of fossil carbon capture and storage (CCS) in the transformation towards a low-carbon energy system	Volker Krey, IIASA
9.2.	An integrated assessment model for the gas upstream supply sector	Daniel Crowe, Imperial College
9.3.	Oil prices and their impact on global carbon dioxide emissions	David McCollum, IIASA
10. Analyses of the low carbon transformation		
10.1.	Low-carbon energy transition: the optimal balance between carbon pricing and technology subsidies	Anselm Schultes, PIK
10.2.	Life-cycle energy demand of the electricity sector	Michaja Pehl, PIK
10.3.	Changes in biomass production and land use in an intermediate mitigation scenario with emissions path from an earth system model of high climate sensitivity	Diego Silva Herran, JAMSTEC
11. Integrated assessment of climate engineering and carbon dioxide removal technologies		
11.1.	Food price impacts following from afforestation	Ulrich Kreidenweis, PIK
11.2.	The role of CCS and negative emissions to achieve stringent climate change mitigation	Matteo Muratori, PNNL
11.3.	Enhanced weathering and BECCS - are carbon dioxide removal technologies complements or substitutes?	Jessica Strefler, PIK