Scientific aspects

Content

1 Description of the research programme

1.1. Problem definition, aim and central research questions

This research program aims to provide high quality information on regional climate, now and in the future, for developing national and regional adaptation strategies.

A central theme in this proposal is the uncertainty about the pace and extent of climate change, both addressing estimating and reducing this uncertainty and coping by society and in decision making. From the scientific point of view the problem is that there are many sources of information on climate change, ranging from pure understanding of the climate system to information from observations and a range of models (and combinations of these). All these sources carry their own level of information, which is very difficult to combine into one estimate of the uncertainty range.

From a societal point of view a major problem is that with the current knowledge about uncertainty it is virtually impossible to make objective cost-benefit-estimates with respect to investments that are sensitive to climate and climate change. This hampers decision making and reduces the commitment of societal actors (including the general public) to put effort and funds in adaptation measures.

Another important issue is that the required information on local climate change for specific sectors is only sparsely available. For many variables obtaining such local information is an enormous challenge, and it is even possible that for a number of relevant variables such information cannot be provided (or is too uncertain for practical use). Here we focus on a limited number of variables for which we have evidence that we can make progress in providing local climate change information.

This defines our overall scientific questions, problems, and challenges. These are:

1. How to quantify the uncertainty of regional climate projections, possibly by assigning probabilities?
2. How to provide the high resolution (time and space) consequences of climate change in terms of the average and extreme meteorological conditions in the Netherlands? And by doing so enabling to answer:
3. How will climate change uncertainties propagate into impact analyses for various sectors?
4. How can we integrate information for various user groups such that it becomes a comprehensive set that is valuable to decision makers and scientifically correct?

These research questions are addressed in various forms in the various work packages. We note that it is impossible to answer these questions in this project fully or even to an approximate level, due to the scientific difficulty and the sheer range in questions. Therefore, these questions should be considered as setting the scene for this project.

The research in this proposal will contribute to the follow up of the KNMI'06 scenarios that will be released in 2012/2013. The basis of these next scenarios will be formed by a much larger set of climate simulations (enabling to better estimate extremes, probabilities and uncertainties) at a (much) higher resolution (enabling to estimate local extremes and regional differences) with a new generation climate models (work in WP1 and WP2). Also links with the user community, climate adaptation and policy will be strengthened (work in WP3 and WP4) to improve the use of information on climate change.

1.2. Programme outline and research approach

As mentioned above, information on future climate and climate impacts is needed to construct climate adaptation strategies. Work packages 3 and 4 will address questions of different sectors directly, including questions of hotspots in Knowledge for Climate. Work packages 1 and 2 will develop knowledge for a next generation of climate change scenarios, currently in development.

WP0: Project management: In order to manage the programme, to monitor its progress, and to safeguard its coherence and integration, the. organization of the programme will apply several instruments. There are specific roles by specific members of the team, such as the Consortium Leaader, the Project Coordinator and the Project Financial Officer. The interaction with the hotspots will be organized via a dedicated contact. The project management will apply several procedures, such as organizing annual meetings with the full consortium and checking the progress of the projects.

WP1: Climate scenario development: mechanisms of local climate change in the Netherlands: Increasing knowledge of processes that directly affect climate in the Netherlands. Since local meso-scale atmospheric dynamics and their interaction with the land/sea surface are important mainly during summer, this season will get most attention here. WP1 will focus on the influence of the land-surface and land use changes, small scale atmospheric dynamics related to heavy showers and storms and the influence of the

North Sea. Showcases will be provided of a new generation climate information obtained from a nonhydrostatic climate model at very high resolution.

WP2: Climate scenario development: time series, extremes and probabilities: Developing knowledge for a new generation of climate scenarios for the Netherlands. We will quantify uncertainties in newest global and regional climate simulations, using probabilistic methodologies applied to regional extremes and climate impacts. In addition, a more complete picture of climate change is obtained by providing examples of synoptic weather events in a future climate setting consistent with the KNMI'06 scenarios. For sea level projections, the focus is on further understanding of processes contributing to sea level changes. The knowledge will guide the development of new climate change scenarios.

WP3: Scenario development for climate change impact: Improved coupling and consistency between models for climate and hydrology, ecology, agriculture, and air quality by incorporating relevant mechanistic links. By the coupled models the propagation of uncertainty on the effects on natural resources will be studied. To do so we will make use of various methods for including climate data into impact models. Also projections of land use change will be incorporated. The derived information on the impacts will be summarized in different forms for presentation to the adaptation community. In a case study we will study how uncertainties are taken into account when developing adaptation strategies. This should result into recommendations of best practices for providing projections and their uncertainties for future boundary conditions

WP4: Climate services: The importance of communication of climate information (including uncertainties) to stakeholders is often underestimated en may result in limited or incorrect use of data. Therefore we focus on improving information exchange in the chain of climate research – impact/adaptation research – decision making and vice versa. We will pre- and post-process climate data and provide assistance during use of the data and information (tailoring). Tailoring is not limited to climate data, but also includes climate impact data. Practical tools are developed to visualize the data on different temporal and spatial scales through web interfaces. Information will be given on the assumptions behind the information, on the interaction between disciplines, and on how the information can be interpreted.

1.3. Innovative aspects and scientific output

WP1

High resolution nonhydrostatic climate modelling is a new and rapidly developing field. The motivation for using this kind of models is that they much better resolve the dynamics of convective clouds, meso-scale circulations and their interaction with the surface. These processes are not only important at the local scale, but also at the larger scales for example through tropical convection (and the link with the global large scale circulation) and summertime continental drying due to feedbacks between land surface and convective precipitation. Here, however, we focus on the local scale. One important example is the investigation of the observed temperature dependency of hourly precipitation extremes (14% per degree) which appears to be considerably underestimated by the present hydrostatic models (about a factor of two), and which could

have important consequences for the increase in short duration precipitation extremes. The expected scientific output is a better understanding (and estimation) of how local processes can act as a local driver of climate change and impacts.

WP2

The innovation in WP2 is in the technical and methodological aspects. We will use the latest available climate model output (from EU Ensembles, CMIP5 and other EU projects) to assess uncertainties. New model results will have higher resolution and will be derived from new experimental set-ups, such as decadal predictions which aim for specific climate information up to 2030. High-resolution atmosphere-only results at unprecedented resolution (30 year runs up to T799 horizontal resolution, in collaboration with EC-Earth partners) will be available as well. New techniques will be used to construct time series for extremes, both with statistical models and with climate models. We will use so-called forcing singular vectors in EC-Earth to generate specific weather episodes. This method has not been applied in climate science yet. The most important processes that determine ice sheet calving are not well known and the research will result in a new collection of data and models. Methodologically, the innovation is in the interdisciplinarity as well. The science output is driven by the needs of stakeholders in the hotspots and this will guide the development of future climate scenarios.

WP3

Many couplings exist between climate models and impact models. However, generally these are made separately for different disciplines and carried out by the scientific community. Therefore, impact projections are not easily integrated, e.g. for ecosystems and agriculture and relatively little attention is paid to the practical use of the projections. In this theme we will make couplings based on a consistent set of climate scenarios for a range of impact models where we cover the scale of the entire Rhine basin to the regional scale of the Netherlands. Also innovative in this WP is that we take into account the effectiveness of various impact projects for decision making in the way couplings between climate models and impact models are made.

WP4

This work package does not focus in the first place on scientific output, but on disseminating scientific data/information to a broader public (scientists, policy makers, etc.) through a web portal, besides the personal contacts between stakeholders and scientists. Innovative in this web portal is the integration of data and information on climate change and the impacts on a wide range of sectors. For this integration we pay explicit attention to background information on how data/information is generated, the way uncertainty is dealt with in the various disciplines, the interactions between sectors and possible gaps in interactions, and the possible consequences for the interpretation of the results.

1.4. Relevance of the research programme in an international context

This research program is focussed on delivering scientifically based regional climate and climate impact information to stakeholders and more specifically the hotspots. It addresses science questions relevant to this subject, and it offers methodologies and dissemination tools to deliver tailored information to users.

These issues are in line with the recently formulated Global Framework for Climate Services (initiated at the 3rd World Climate Conference, WCC-3, Geneva, 2009). The work is embedded in world-wide research programs such as the World Climate Research Program (WCRP) in which many applicants participate. The science in the program relates to many European Framework Projects, such as ENSEMBLES, IS-ENES, COMBINE, EURO4M and WATCH. Generated knowledge will contribute to assessments of IPCC. The services in the program are developed in collaboration with European institutes with ample expertise in providing services, SMHI and DWD, and will contribute to developing European climate services.

WP1

This work follows up on the longstanding work on regional climate modelling in the EU projects FP5 PRUDENCE and FP6 ENSEMBLES. It links with the new WCRP regional downscaling program CORDEX (coordinated regional climate downscaling experiment). It also contributes to a growing effort from different several EU countries (Sweden, Danmark, Ireland, The Netherlands, Spain) to develop a joint regional climate model based on HIRLAM/HARMONIE system.

WP2

The work is embedded in international activities to develop climate scenarios as coordinated by WCRP and carried out in a number of European Framework programs (EU FP7 COMBINE, THOR, IS-ENES) and process studies (ICE2SEA).It follows naturally on these and existing programs in which the leading scientists are involved. The analysis of uncertainties is key to the evaluation of model output, which is organized through WCRP (CMIP5, CORDEX). New methodologies are propagated by WCRP as well, for instance, through the Task Force on Climate Extremes.

WP3

The work makes use of the results from international climate scenarios projects as ESSENCE, ENSEMBLES, EUwater scenario studies as SCENES, and projects on the climate effect on a river basin scale as KLIWAS, RHEINBLICK and AMICE. It adds new insights by integrating the results for the case of the Rhine/Meuse delta and translating these into effective scenarios for adaptation strategy development.

WP4

There is ample international collaboration and coordination in the field of climate modelling, but not in the field of climate services. However, the past years many countries started to set up national climate services for future climate information. More recently international cooperation in climate services got a lot of attention through the development of the Global Framework for Climate Services (WCC-3). Until now this consisted mainly of contacts between the various countries. The international workshop on climate services in September 2009, De Bilt, provided an overview of activities in European countries, and showed that many countries deal with the same type of questions and can learn from each other. In this theme we aim at making an inventory of current best practices and start actual collaboration between European nations in a specific case study. This will contribute to increased international collaboration on climate services. This is relevant in particular for cross-border issues such as river discharge.

1.5. International cooperation

SMHI has a large expertise on regional climate modeling and downscaling, and has strong links with the application/impact community. The regional climate modeling center at SMHI is one of the leading centres in Europe.

DWD has a large experience in weather services, also through internet, and is now cooperating in the new Climate Services Centre in Germany.

The science is internationally embedded in research programs (see above). We will employ EC-Earth in 2 projects in WP 2. EC-Earth is developed in an international consortium of 22 institutes from 11 countries. The model is based on ECMWFs seasonally forecast system. The project follows a seamless prediction strategy. The consortium will contribute to CMIP5 project of the World Climate Research program. Through our activities in European programs on climate scenarios and climate processes we will continue international collaboration.

The regional (hydrostatic) modelling effort in WP1 has strong links with the European project ENSEMBLES, in which a large ensemble of regional climate model integrations has been developed, We will use this data, complemented with a large number of additional runs done at SMHI, to provide probabilistic data on climate change in WP2and setting boundaries for the nonhydrostatic modelling in WP1. The nonhydrostatic model HARMONIE is developed with the international numerical weather prediction HIRLAM community in collaboration with the AROME/ALADIN community led by France. Many of the partners (including SMHI) within HIRLAM expressed their interest in a climate version of HARMONIE.

Exeter University focuses in particular on management and communication of uncertainties in assessing climate change impacts, vulnerability and adaptation options. The contribution of Exeter University to Theme 6 will be made through sharing insights obtained from experiences in the United Kingdom and providing advice on dealing with uncertainties in climate adaptation, based on the state of the art expertise at the international level.

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2 Interdisciplinarity

Society is mainly interested in the impacts of climate change, and less in the change of climate parameters (e.g. temperature, precipitation). For determining the impact of climate change and possible adaptation options interdisciplinary research is needed. Often, impacts and adaptation options in one sector are

influenced by impacts and adaptation options in other sectors. This also can only be solved by an interdisciplinary approach. In this theme ample attention is paid to this aspect:

- The set-up of this proposal is based on many stakeholder consultations from a wide range of disciplines in the past years in the Climate Changes Spatial Planning programme and in the first tranch of the Knowledge for Climate programme, and the selection of subjects is guided by the requirements of stakeholders.
- A wide range of impact modellers are included as partners in this theme and WP3 focuses completely on the coupling of climate and impact models
- WP4 focuses on improving the 2-way communication in the chain of climate research – impact/adaptation research – policy makers.

In the following more detail is given per work package.

WP1:

Traditionally, climate research is dominated by large spatial scales and long time scales, although impacts of climate change will be mainly experienced at a local scale. The weather prediction community focuses on higher spatial scales. In this project, the bridge is strengthened between the climate research and weather prediction community in order to provide the best information of climate change at the local scale.

WP2:

Current climate projections are mostly guided by (physical) climate science. The inclusion of climate impacts adds an interdisciplinary component. Furthermore, the climate impacts that are studied are driven by needs defined by stakeholders. By working with WP3 and WP4 we will obtain further information on the use of scenarios. Thus the further development of the scenarios will be guided by both physical climate science and stakeholder needs. Within climate science, we will try to bridge the gap between weather forecasting and climate research by applying weather prediction techniques in climate modelling.

WP3:

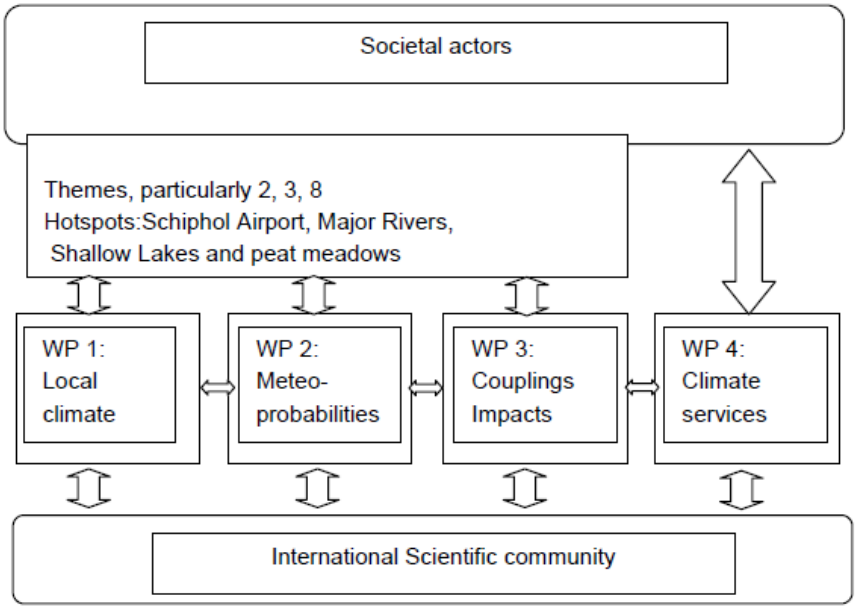
In WP3 we integrate the climate research results with impact and adaptation research. We provide projections of the impacts of climate change for the water, nature and agricultural sectors. Additionally we evaluate different methods to provide the impact projections that can be used for developing adaptation measures. A study is made to the similarity and differences in types of couplings between impact and climate models in order to assess the possibility to develop consistency in coupling methods and climate data use over the various disciplines.

WP4:

This WP aims to integrate data/information of esp. climate, hydrology, ecology, agriculture, land use, and includes among others overview of similarities and differences in approaches in modelling, dealing with uncertainties, assumptions, and identification of possible discrepancies, interactions between sectors. The partners involved have experience with this interdisciplinary work in several other projects. Besides, an interdisciplinary expert pool is created for additional questions for data and information (also integrated data sets) in this WP.

3 Coherence between and synthesis of outcomes from the individual work packages

The project is organised in a chain (see figure) from production of high quality climate projections to the specific information required by a variety of stakeholders. Crosscutting themes are dealing with uncertainty and integration of monodisciplinary approaches. WP1 is about reducing uncertainty through analyzing regional climate feedbacks. In WP2 an attempt is made to assess uncertainty with probabilistic methods. WP3 and WP4 are about translating to impacts, mapping the uncertainties and communicating to various societal sectors.



The chain is primarily connected to the international scientific community by WP1-2. At the side of WP3 and WP4, the project and its participants are well connected to society. The elements of Theme 6 were explicitly discussed with hotspot representatives and Theme coordinators. The consortium will stay in close contact with stakeholders through ongoing cooperation and stakeholders meetings.

WP1 provides results from regional climate simulations to WP2 where they are used to assess uncertainties, and to WP3 where they are used to estimate climate change impacts. On its turn WP1 gets large-scale driving conditions from simulations performed in WP2 in order to downscale these further by employing non-hydrostatic models to the km scale. These very high resolution cases studies will be inspired by user requirements in WP3/4 and from the different hotspots involved (Schiphol, in particular).

WP2 will provide information on uncertainties at different time and spatial scales to be used for coupling to impacts. It will make use of regional climate model simulations performed in WP1, and simulations performed within the wider scientific community. Information on how climate impact modellers and end-users use uncertainty to develop adaptation strategies will be provided by WP3 and WP4 in order to provide guidance to developing new climate scenarios in WP2. Information on uncertainties and new methodologies of generating time series will also provided to (and exchanged with) WP4.

WP3 incorporates a larger variety of scientific fields. Consistency is preserved by two general activities. All scientists contribute to the research towards more general approaches to coupling effect models to climate models. Secondly, all scientists will contribute to analysis of the selected specific sectors. WP3 obtains information on climate change (high resolution, time series and uncertainty estimates) from WP1,2, and will provide information on climate change effects and impacts for different sectors as well as recommendations for presentation of scenarios for different sectors to WP4.

WP4 aims to disseminate the information that comes available from WP1-3 to a broader public, where necessary modified into a form appropriate for the intended stakeholders. Researchers from WP1-3 will be asked to review the modified results. Information on how stakeholders use and perceive uncertainties in order to provide guidance to developing new scenarios will be proved to WP1-2. WP4 will cooperate with WP3 to create an integrated dataset of climate change and impacts for a limited number of combinations of climate scenarios, spatial scenarios and time horizons. WP4 will organise stakeholder consultations, and may ask scientists from WP1-3 to participate in this. WP4 will give feed back on stakeholder needs to WP1-3.

4 (Expected) cooperation and coherence with other research themes

The cooperation with the other themes is as follows:

Theme 1.
The uncertainty assessments of future climate of T6 (theme 6) can be used in theme 1 for uncertainty assessments of future water safety. Through land use T6WP3.4 (theme 6, work package 3.4) contributes to flood hazard assessment.

Theme 2.
In T2WP2 in cooperation with T6 consistent sets of boundary conditions for the fresh water use in the Netherlands will be developed. T6WP3 can be applied to the integrating case of T2WP6. The climate uncertainty results of T6WP2 can be applied in T2WP5. The same impact models are used as in T6.

Theme 3.
The results obtained with the land use model in T6WP3.4 are used in T3, and this model is further developed in T8. A strong link exists between T6WP3.2, agronomic models, and T3WP2, farms of the future and their vulnerability to climate change. T6WP1, particularly its results on extreme precipitation, can be of value for T3WP3, in which a climate-proof assessment is made at the field level of climate-crop production interactions, including the effect of weather extremes. The same impact models are used as in T6.

Theme 4.
In T4 important input is expected from T6 on regionalized climate projections. Cooperation en coordination is expected between T4 and T6 on the use of measurement data and models. T4WP1 is an interface project with T6, on assessing the impact of future climate projections and adaptation measures on urban climate. T6WP1 has a link to T4 with respect to urban hydrology.

Theme 5.
T6 will be of use for T5WP1, in the development of a model that consistently describes the propagation mechanisms of climate change on infrastructure and networks, and the associated economic impacts. T6 will also be of use for T5WP2, in which the vulnerability and tipping points of infrastructure assets is determined, based on different climate scenarios. T6WP1 also has a link to T5, for example with respect to extreme weather conditions at Schiphol airport.

Theme 7.
Cooperation between T6WP3 and T7 is envisaged on dealing with uncertainties. T6WP3.6, a case study for assessment of climate change uncertainties, is cooperating with T7.

Theme 8.
A link between T6 and T8WP6 exists on a cost benefit analysis. Hereto detailed methods are developed that can be applied in various case studies in a consistent manner, considering the future climatic change, based on climate scenarios. T6WP2 has a strong link to T8 on the application of uncertainties in decision making.

Bouwstenen NAS
The web portal in T6 will give the necessary basis for the geoportal of Bouwstenen NAS, which can include e.g. maps and summaries of the web portal from T6.

Knowlegde Transfer
The web portal developed in T6WP4 can be used as a tool in existing Knowlegde Transfer within KfC, to show stakeholders what information is available and to give them an overview.

5 Connection to finalized and current projects in KfC and other research programmes

WP1

- Builds on model development towards a high resolution regional climate model RACMO and understanding to role of the North Sea in project CS5/CS6 of CCsp, and KKF Future Weather of KfC.
- Builds on the development and application of a nonhydrostatic climate model in the project IMPACT of KfC.

WP 2

- Builds on KKF Future Weather Project of KfC where uncertainties in large scale circulation and its impact on regional climate is addressed. Here the implications are further investigated to guide scenario development.

- Builds on development of seamless prediction strategies and the development of EC-Earth (European consortium from 11 countries developing an earth system model based on ECMWF forecast systems).
- Builds on different EU Framework projects on models and scenarios: ENSEMBLES, COMBINE, IS-ENES, EUCLIPSE, ICE2SEA. Applicants are actively involved in those projects. Results from these projects will be used.
- Relates to recently awarded NWO sustainable earth projects, such as the EC-IMAGE project, where feedbacks in the climate system are further investigated.
- Builds on CcSP projects AVV2 on scenarios for river discharge.

WP3

- Builds on climate projections obtained from the EU Ensembles project and their hydrological effects from the RHEINBLICK project.
- Additionally WP3 builds on BSIk-A1 and BSIk-A2 projects.
- In the Climate Changes Spatial Planning programme study no. IC11, socio-economical scenarios assessments have been made for changes in flood and drought risk. Comparable assessments have been made in studies carried out to develop the national water plan. The results of these studies will be integrated here.
- The evaluation of effective ways to provide scenarios builds on results obtained from studies financed by BSIK- Living with Water.
- In the first tranch of the KKF a coupling between simulation models that describe the hydrological response between the Alps and the boundary North-sea/Atlantic ocean is under construction. It is this system that will be used here and of which the results will be tailored for adaptation design purposes. In the same project a design is made for coupling of other environmental models (nature, agriculture), and land use planning models. This coupling will be implemented here. Additionally we will build upon the development of the coupling of high resolution regional climate models and air quality models.

WP4

- builds on projects in CCsP (mainly data and information from the Adaptation theme), but also on experiences from the CS7 project on Tailoring of climate data (e.g. experience that users/stakeholders want overview and integration/consistency). Data/information from these projects will be included in the web portal. The same counts for the projects COM21 and COM27 (climate effect atlas). The project COM28 was set up to deliver additional data to CCsP projects (requests that generally could not be foreseen earlier). Because of the experiences with this project, an expert pool for additional data requests was included in this theme 6
- In the first tranch a first pilot of the web portal is constructed in the KKF-T project, and a first user/stakeholder consultation took place on November 10 2009, where all project leaders from KfC in the first and second tranch where invited. In this theme 6 the pilot will be further elaborated (more data and information will be included). The information from the user consultations will be used to modify the set-up and/or content.