Project Plan

SBW \ Boundary Conditions \ Wind Modelling

Part 1: General project description

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1. Introduction

1.1 About this document

Purpose of the document

A good description of the wind, as a driving force behind water level increases and wave generation, is important to the assessment of Dutch flood protection. The quality of the current wind description is lacking in a large number of components, in part because of this importance. Work is already ongoing from a number of different perspectives to improve some of the components and plans are being made for the improvement of others. However, most of the items that require improvement are not being dealt with. In short: there is fragmentation and gaps in the approach to dealing with the required improvements to the wind models. Coordination is required for a balanced and efficient approach. The intended purpose of this document is to be a plan for this coordination.

This approach can be embedded in the SBW project at diverse crucial points that require improvement. However, this is not useful or essential for *all* the developments in wind modelling. The aspects of division and prioritisation can be matter for discussion. This document is a proposal for a coordinated strategy.

The document is comprised of three sections. 'Part 1' describes the general strategy for the wind modelling problems. 'Part 2' provides a more detailed description of the wind modelling problems and the proposed activities. The third section consists of annexes. Each section has its own list of contents.

The breadth of the concept of 'wind modelling'

Within the current context, the term 'wind modelling' focuses on providing adequate and accurate wind information for the assessment of the Hydraulic Boundary Conditions, such as:

- wind speed and direction in space and time, as input for water level models and wave models
- wind drag formulation(s) to be applied in the models for wind, water levels and waves
- wind statistics, as input for the probabilistic models (Hydra family)

See Annex 3 for more background information on the HBC model chain and Annex 4 for the Hydra philosophy.
The term 'wind modelling' is related to the description of *both* the physics *and* the statistics of wind as input for HBC computations. Within the current context, the term 'wind modelling' *does not* intend to provide a meteorological model or climatological model; we aim at a far more pragmatical modelling than that type of models.
Please refer to section 2.3 for a further delimitation of the topic.

Previous history and framework

The history of this strategy can be outlined using a few crucial documents. The present strategy is a direct consequence of the HKV study into the current status of our knowledge in respect of wind, for use in flood protection (Lammers en Kok, 2006). This study used a number of interviews and a brief literature study to form an impression of the current status of knowledge. The analysis showed that:

- The effect of wind on the water system is indicative of the loading on a large part of the Dutch dikes.
- The TAW[1] has several reservations regarding the wind modelling methods used until now.

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[1] TAW stands for Technische Adviescommissie voor de Waterkeringen (*technical advisory commission for the water defence structures*). This commission was dissolved in 2005 but generally continues to operate under the

- Long term KNMI research that was initiated on the basis of TAW advice has resulted in insufficiently consistent, and insufficiently explainable, results.
- Existing wind-related knowledge is not adequately applied.
- And there are crucial knowledge gaps in four areas.

All this argues strongly for a stronger focus on the aspect of ‘wind’. And this is the motivation behind the work contained in this document that focuses on making detailed plans for the improvement of the wind models.

The HKV study was based not only on the interviews, but also a number of other documents, including:
- The KNMI publications on the wind climate in the Netherlands (Wieringa en Rijkoort, 1983) and the Rijkoort Weibull model (RW-model) for the description of the wind statistics (Rijkoort, 1983), both from 1983.
- The report from the KNMI Hydra project (1998-2003). This was a large cooperation project, involving KNMI, RWS-RIKZ and RWS-RIZA, that was designed to update the wind statistics in the Netherlands for the HBC. However, although it revealed a great deal of information and carried out in-depth analyses, the project did not produce any final results that were of practical use in the HBC determination. See the summary (Verkaik et al, 2003), for example.
- The RWS-RIZA report on the application of the RW model within the framework of the Hydraulic Boundary Conditions for fresh water areas: statistics in (Geerse, 1999), physics in (de Waal, 2003) and an additional memo on the unresolved problems in (Bottema, 2005).

The abovementioned HKV study was carried out within the framework of the SBW project. This project was initiated in 2003 as a cooperation project between the RIKZ, RIZA and DWW departments of the RWS, but remained idle throughout 2004 and 2005. The project was restarted in 2006. In 2006 and 2007, an important role was reserved for WL Delft Hydraulics in the SBW project as a whole, in part because of the redistribution, that will start in 2008, of knowledge (experts) among the Water department at RWS and Deltares.

Parts of the planning for SBW and its units are still under development. The general plan is described in (Haskoning, 2006). Extracts from this plan is included as Annex 2 of this document. The proposed strategy in this document for dealing with the wind model is a result of working out the details of one of the components of the above plan.

Target group for this document

For the time being, the target group for this document is comprised primarily of people involved in:
- The planning for the entire SBW project.
- The planning related to wind modelling in relation to flood protection in a broader context than solely SBW.

The reader is presumed to be familiar with:
- The general contents and terminology of the HBC (Ministerie van Verkeer en Waterstaat, 2001) and the VTV (Ministerie van Verkeer en Waterstaat, 2004).
- The SBW project plan and strategy (Haskoning, 2006).
- The HKV report on the current status of wind-related knowledge in respect of flood protection (Lammers en Kok, 2006).

The document is therefore not written for a broad public.

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new name of Expertise Netwerk Waterkeringen (ENW: *water defence structures expertise network*). However, the ENW has a slightly different role to that of the TAW. See http://www.tawinfo.nl/.

1.2 General requirements for wind modelling

1.2.1 Substantive questions

The substantive needs of wind modelling for the HBC determination can be summarised as follows (Lammers en Kok, 2006):

1. The *existing knowledge* is not being adequately applied and it is striking that the current statistics are based on a short time series and that there is inconsistency between the wind models for the different water systems.
2. It is also essential to *develop new knowledge,* in particular in respect of the following four topics:
   a) How do we translate the wind (statistics) that are available for above land into wind (statistics) for use above water?
   b) How must extreme storms (wind fields in time and space) be represented schematically when managing the models for water levels and waves for use in the HBC?
   c) Which model of wind roughness is most suitable for application in the models for wind, water levels and waves?
   d) Which influence does climate change have on the statistics of (extreme) winds?

For a more detailed description of the material status and the needs related to wind for the HBC, please refer to (Lammers en Kok, 2006). Part 2 of this document also details the needs on the basis of the general strategy as specified in Chapter 3.

1.2.2 Perspectives

The need for good wind models in relation to flood protection has arisen from a number of different perspectives and activities. It is not practical to try to combine all the goals in a single project. However, it is desirable to make maximum use of the common interests. The following is a more detailed description of the most important of the different perspectives that have partially overlapping interests.

Assessment

The Hydraulic Boundary Conditions (HBC) must be specified every five years for the statutory prescribed Assessment of the Dutch water defences, which must also be performed every five years. Wind models are used in the determination of the HBC. These wind models are also an implicit part of a statutory calculation instrument for the Assessment. On the one hand, this fairly serious status places serious requirements on the correctness and accuracy of the model, whereas on the other hand a great deal of value is put on consistency, robustness and broad-based support. Considering the current status of knowledge, this ‘on the one hand’ prompts us to achieve improvement, while the ‘on the other hand’ means that no chances can be taken when implementing new insights, which will therefore take time. This is an important area of tension within the process of improving wind models as a part of the HBC instrument. The primary goal of the SBW and HBC[2] projects is to improve the wind models in the statutory instrument for the assessment. Within this context, there is also a clear relationship with time: the instruments, such as the wind model, must be up-to-date in 2008 for the Wadden Sea HR2011. The 2016 edition of the HBC is the primary client for wind model developments that go further than simply bringing it up-to-date.

[2] The exact delimitation of what must be performed within SBW and HBC respectively, has not yet been crystallised.

Design

In the present framework, the term 'Design' is related to all (plans for) changes in the water system that could affect the (assessment of) flood protection. Design is therefore not only related to dike reinforcement but also to aspects such as dike repositioning (RvR), changes in the management of a riverbed, the management of storm surge barriers and the use of drainage sluices. Design has a lot of similarities with Assessment. However the main differences involve the period they view (Assessment examines the current situation and Design looks at the situation for the next decades and uses elements such as a *climate scenario*) and how they deal with uncertainties ('Stringent Assessment' versus 'Robust Design'). For the time being, there is no statutory prescribed instrument for Design[3]. However, the Assessment instrument will often be used in practice, with additions for climate change and, if required, for uncertainties. Wind models will therefore also play an important role in Design.

Investigations and policy studies

There is a third type of study besides the practical studies of Assessment and Design: the Investigations and Policy Studies. These studies often have a 'what if…' character and frequently apply not just to a single water system but to all of the Netherlands. Examples include the investigations into innovations in the philosophy of protection (flood risk strategy) and investigations into the implications on protection of the different climate scenarios. Wind modelling can also be an important aspect in this type of study. Consider, for example, the uniformity (consistency) of the models across the different water systems, the availability of climate scenarios for (extreme) wind, and the flexibility of the modelling for the computation of wind climate scenarios.

Operational expectations

The previous three perspectives are related to flood protection in terms of risk or frequencies per year. You could call this 'statistical protection'. Another, entirely different but related, branch is what we could call 'operational protection'. This designation is related to the expected protection for the next few days. This concerns in particular those situations during which KNMI issues a storm related 'weather alert'. The relevant question is then: what effect will the coming (extreme) weather conditions have on the flood protection.

There is already close cooperation in this area between the KNMI and the RWS warning departments. Within this cooperation, work is also proceeding to improve the computational models for wind, water levels and waves. There are many similarities between statistical protection and operational protection, in terms of the required knowledge and computational models. One important difference concerns the availability of specific measurements related to the recent past of the storm, in particular the parameters such as temperature and air pressure, that are not taken into account for the statistical aspects of protection.

1.3 Lessons from the past: development and application of knowledge

In the past, the developments in wind modelling in relation to flood protection has often taken place on a local ad hoc basis. This has resulted in differences between the wind models for the different Dutch water systems[4]. In themselves, such differences do not have to be a problem: after all, the character of the water system will determine which pragmatic solutions (simplifications) are permitted in the wind models, and which are not. There is a suggestion that not all these choices were made equally deliberately. And this is an undesirable situation.

[3] However, work is currently being carried out on a 'Design Technical Report'. Although this will not be given a statutory status, it will have the necessary authority.
[4] Differences can even occur within the models for a single water system, such as in respect of the wind drag formulation in the individual models for wind, water levels and waves.

Another aspect that plays a role here is that only a relatively limited number of people have studied flood-protection related wind models, either now or in the past, which means that even a normal level of staff turnover has major consequences. In many cases, it is no longer possible to identify the considerations that were the basis for choices made in the past regarding wind modelling. Knowledge management in this area is therefore a worrying issue.

Despite this, we now also have some *opportunities*: flood protection, climate and climate change, innovation and the knowledge economy are 'hot items'. There is also an ongoing reorganisation of the water related knowledge infrastructure:

- The expertise in and coordination of knowledge development in the three specialist RWS departments of RIKZ, DWW and RIZA have been combined into a single national RWS department: the Water Department.
- In respect of GTI, the expertise in WL, GD, parts of TNO and parts of RWS have been combined into a single institute: Deltares.

In this reorganisation, the ambitions of the new Deltares institute in particular form a good framework for setting up an enduring form of knowledge management and the establishment of collaborations (knowledge alliances) with bodies such as the KNMI.

In summary, the following aspects are important to efficient knowledge development:

- Enduring knowledge management and good documentation.
- Coordination, harmonisation and cross-pollination between projects with overlapping interests.
- Promotion of and familiarity with the coordination, obtained through good PR.

2. Project description

2.1 Problems and goals

Problem

The current models of the wind, both physical and statistical, that form the basis of the assessment of flood protection in the Netherlands have a large number of shortcomings. As wind has an important, causal role in the threat to the water defences, there is a high probability that these shortcomings will result in an erroneous judgement regarding flood protection.

Primary objective

The primary objective is an improved model of wind, both physical and statistical, that will form the basis of the assessment of flood protection in the Netherlands.

Products

The products will include a minimum of a set of computational instruments including the associated base information and accompanied by comprehensive documentation.

2.2 Wishes and requirements

Requirements

- An understanding is required of the uncertainties in the different aspects of the wind modelling as well as of the contribution of these uncertainties in the uncertainty related to the correctness of the protection assessment.
- The term ‘improved’ in the primary objective means that the (contribution towards the) uncertainty related to the correctness of the protection assessment must be demonstrably reduced.
- It is necessary to have a support base of policymakers, experts, scientists and users. This implies that the modified wind models must be unambiguous, consistent, reproducible, properly documented and practically applicable.
- The modified wind models must at a minimum be related to the current climate and it must be possible to expand them with climate scenarios for the future.
- The delivery dates for (partial) products must be coordinated with the plans for the 5-year editions of the HBC.

Wishes

- It is desirable to have an understanding of future wind climate changes. On the one hand there is a need for wind-related climate scenarios and on the other hand there is a need for the rapid calculation of the implications of such wind climate scenarios for flood protection.
- It is desirable to have long term knowledge management.
- Coordination between international knowledge, (measurement) information and computation methods is desirable.

2.3 Delimitation

- The project only considers aspects of wind modelling that are relevant to the *Dutch* situation, so modelling of situations such as tropical cyclones is not included.
- The project only considers aspects that are important to *flood protection*: primary water defence structures, Flood Defences Act.
- The project only considers the role of wind *via the water*, in this case the water levels and waves, and not as direct wind loading on parts of the water defences.
- The improved wind models will have the status of ‘*advice on the basis of technical considerations*’. Policy considerations also play a role in the question of whether these models are actually applied in the calculation of a new edition of the HBC. This policy consideration is not covered by the scope of this project.

2.4 Boundary conditions and starting points

Starting points

- The current wind models for the HBC up until the 2006 edition form the starting point and the reference framework for the improved wind models. We are not starting with a blank sheet. Developments and modifications must be based on the current methods and be demonstrably better.

Boundary conditions

- The measurement data from the KNMI must be available.
- Cooperation is required from the KNMI in the area of weather models (hindcasts).

NB: We assume that a great deal of the work in the area of wind modelling will be carried out by the KNMI, which means the above boundary conditions will be fulfilled automatically.

2.5 Organisation: embedding in the SBW project structure

Important parts of improving the wind models will be carried out within the SBW project. The wind modelling strategy is a separate subproject[5] within this project, namely the 'Boundary Conditions' project cluster.

SBW \ Boundary Conditions \ Wind Modelling

The Wind Modelling subproject has strong connections with the following subprojects:

SBW \ Boundary Conditions \ Statistics and probability modelling
SBW \ Boundary Conditions \ Wadden Sea HBC
SBW \ Field Measurements

2.6 Relationship with other projects outside of SBW

There are relationships with many projects outside of SBW. These will be mapped out in more detail during the coordination activities. Here are a few examples:

- HBC-assessment and HBC-Instrumentarium (including the Hydra family)
- VNK, PCRing
- Effects of climate change
- Operational expectations: SVSD / WDIJ (Model development, Atlantis; hindcasts)
- KNMI projects: measurements, hindcasts, climate models, wind drag etc.

3. Plan of Action

3.1 Introduction

This document specifies the general plan of action. The work on wind modelling will run a parallel course, even if this is only because certainly not all the activities are part of a single project or are the responsibility of a single, central management. The details of this plan of action should therefore be worked out in the separate projects. In accordance with the accepted procedure, the plans will be refreshed each calendar year.

Part 2 of this plan provides an indicative overview of the plan of action. Several underlying causes are presented below.

3.2 Work packages and projects

There are many different ways of dividing up the necessary wind-related work. Each division has its pros and cons depending on the intended purpose of the fragmentation. For the time being, we have

[5] The nomenclature for the different layers within the project hierarchy has not yet been standardised.

decided to use a division that provides perhaps the best stepping stone for the formulation of subprojects and projects. However, the division is certainly not perfect as there are still a number of interdependencies.

The division into Work Packages (WPs), that has been chosen for the time being, is as follows:
1. Wind modelling **problem analysis** for flood protection.
    a) Why do we have to work on wind modelling? (target group: managers)
    b) How and when should which aspects be dealt with? (target group: users and researchers)
    c) Coordination, formation of knowledge alliance, PR.
2. Wind **modelling** for **HBC**: **make it up-to-date and consistent**
    a) Update contents of wind modelling, in particular the statistics: Supervision of HYDRA-WIND-II project
    b) Method of application when making HBC consistent
3. Wind **modelling** for **HBC**: **innovation**
    a) Investigation of opportunities for innovation
    b) New storm schematisation in application
    c) New storm statistics: statistics of wind fields in time and space
    d) New wind-water interaction
4. Map out **effects** of wind **climate change**
    a) Formulate wishes in respect of climate scenarios: which wind parameters do we need?
    b) Develop or modify instruments for computing the implications of wind climate scenarios
    c) Map out the implications of wind climate scenarios
5. Wind **measurements** for use in statistics, storm description, land-water transitions and wind drag
    a) Collect measurement information
    b) Aggregate wind measurements

Explanatory note:
- WP1 forms the basis and the starting point of the project. WP1 secures support for investment, draws up a widely supported plan of action up and pursues efficiency by investing in coordination.
- WP2 is most closely associated with the short term needs of the HBC: improvement, but no major steps. The work is reasonably clear and can be gauged *relatively*[6] well.
- WP3 is also necessary because the current wind models have fundamental problems. But WP3 probably forms a large step in relation to the current approach and will therefore require considerable time before it is accepted into the HBC[7]. W3 is much more difficult than WP2 to define and plan, both in terms of content and acceptance process, and is therefore not suitable as a method for HR2011.
- WP4 is desirable but can perhaps be dealt with primarily outside of the SBW framework. Strictly speaking, studies into climate change are not part of the work associated with the HBC, and therefore not for the SBW, even if the SBW plan of action does include some latitude for this.
- WP5 is of fundamental importance to the project. The routine part[8] of the measurements do not come within the scope of the SBW, whereas the specialised part of wind measurements SBW do. The measurement *needs* ensue from the other WPs within ‘SBW / Boundary Conditions / Wind Modelling’. The *implementation* of the specialised measurements is the responsibility of under ‘SBW / Measurements’.

A more detailed explanation of the content of these work packages will be given in part two of this document. For the time being, this will primarily specify focus points or work areas. The more detailed implementation in the form of a project plan for each component, has not yet been carried out. The actual plans should include the standard project plan topics as well as the following aspects:

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[6] It is hard to give the word ‘relative’ sufficient emphasis here as the material is very complex and still contains unresolved problems.
[7] Compare this example to the process of giving the precipitation generator a role within the HBC determination.
[8] This includes such things as the standard observations from the KNMI measurement stations.

- Actually making the problem and goal measurable (quantifiable) (see the requirements in section 2.2).
- The manner in which developments are used from related projects, outside of SBW.
- The manner in which knowledge and information from abroad and related areas of expertise are used.

4. Planning (SBW)

The planning and completion of the different partial products within the framework of wind modelling will be aligned with the requirements of the 2011 and 2016 editions of the HBC. The highest priority for the 2011 edition of the HBC is for the computation methods for the Wadden Sea.

5. Costs (SBW)

[Information regarding costs has been omitted from this version of the document.]

6. Organisation (SBW)

6.1 Involved parties and division of roles

The following people have so far been involved in initiating the Wind Modelling project:

Content:
- Hans de Waal, RWS-RIZA (Deltares)
- Douwe Dillingh, RWS-RIKZ (Deltares)
- Houcine Chbab, RWS-RIZA (RWS-WD)
- Job Verkaik, (KNMI) Vortech
- Henk van den Brink, KNMI
- Chris Geerse, (RWS-RIZA) HKV Line in Water
- Ton Vrouwenvelder, TNO
- Sofia Caires, WL Delft Hydraulics (Deltares)

KNMI management:
- Gerrit Burgers, head of the 'Research' department in the 'Weather' product cluster
- Arnout Feijt, head of the 'Climate data and advice' department in the 'Climate' product cluster

Committee members:
- Andries Roelfzema, WL Delft Hydraulics / RWS-RIKZ (Deltares)
- Marcel Bottema, RWS-RIZA (RWS-WD)
- Ellen Claessens, RWS-RIZA (RWS-WD)

6.2 Communication

The internal communication within the SBW project is for an important part dependent on the project structure, which has not yet been entirely crystallised.

In the first instance, we adhere as closely as possible to the agreements on external communication that relate to the SBW project as a whole. However, additional agreements may be necessary for the desired initiatives within the framework of coordination and the exchange of knowledge and information.

6.3 Quality assurance

In the first instance, we adhere as closely as possible to the method used for quality assurance within the 'SBW \ Boundary Conditions' umbrella project. The Hydraulic Review Team (HRT) plays an important role in this[9]. As the original composition of the HRT primarily included expertise in the area of hydraulics, it has now been expanded with an independent expert in the area of wind modelling. All this has been established in close cooperation with Hans Janssen (RWS-BD, contact for SBW \ Quality Assurance).

Deltares will also use an internal quality assurance system. The details of this system are not yet available.

[9] The HRT also provides quality assurance for those parts of the 'SBW \ Measurements' that serve 'SBW \ Boundary Conditions'. This includes the measurement campaign in the Wadden Sea.

Project Plan

SBW \ Boundary Conditions \ Wind Modelling

Part 2: Detailed contents of the work packages

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Introduction

This document is part 2 of the draft project plan for work within the framework of the SBW \ Boundary Conditions \ Wind Modelling project. Part 1 provides a general description. We strongly recommend that you read part 1 before reading this document, which is part 2.

Part 2 contains a summary of the focal points in the different work packages. This summary is intended to help generate a more detailed impression of the required contents of the work packages and the question of what could and could not be carried out within the SBW project. This only concerns the contents of the work packages. The project management will not be described in any more detail in this document.

1. WP1 Problem analysis, planning and coordination (SBW)

Introduction

Work package 1 is comprised of three sections. In the first instance, this is a study to substantiate the need for improving wind modelling. Starting from the conclusion that this need is present and has sufficient support, the second part of the problem analysis is a plan of action to improve the wind modelling. As it is already clear that not all the components in a plan of action will be carried out within a single project, communication and coordination between the different projects is an important issue. This is the third and last item in this work package.

1.1 Analysis of the need to improve the wind modelling (SBW)

The study to substantiate the need to improve the wind modelling was carried out by HKV in 2006. The study resulted in two products:
- A management summary of the findings in the form of a 4-page pamphlet.
- A background report about the method and findings of the study (Lammers en Kok, 2006).

The pamphlet was submitted to a number of involved parties for their information and comments. Although the core message of the pamphlet was not disputed, a number of different wishes were expressed to modify the pamphlet. After a number of attempts to produce a widely-supported final version, it was decided not to invest any additional time and money in it. As a result, the pamphlet was not published.

In addition to the products from this HKV study, Hans de Waal made presentations to a range of committees on the problem of, and the need for, investing in knowledge:
- SBW kick-off (Leeuwarden, 31-01-2006)
- Hydraulic Review Team (Delft, 18-09-2006)
- SBW \ Boundary Conditions \ Wadden Sea HBC project group consultations (Delft, 12-12-2006)

The intention was to give similar presentations in several other committees. However, the required goal of obtaining support for investments in wind modelling within SBW had already been adequately realised. The priority was therefore shifted to the next stage: working out the details of the plan of action (see section 1.2).

Giving presentations to the different parties on the problems related to wind modelling will obviously continue to be a worthwhile activity. However, subsequent presentations would better be combined with a presentation of the main features of the strategy for dealing with the problems. It is very desirable to obtain support for this from HRT and ENW.

Products: report and pamphlet[1]
Status: completed

[1] In the end, the pamphlet was not published.

1.2 Drawing up the plan of action (SBW)

The plan of action is comprised of two components:
- A general plan.
- The material details of the different components (= this document).

This plan will be produced in consultation with:
- The material experts on wind modelling for flood protection.
- The project management at SBW (client, project leaders, steering committee, quality assurance group).

It can be decided in consultation with these involved parties whether a workshop could provide a worthwhile contribution towards achieving a widely supported plan of action.

Products: Project plan (living document).
Status: The draft material description of the components is currently being discussed.
Schedule: Complete the plan in August 2007 and discuss in the HRT on 10 October 2007. The plan will then be scrutinised periodically and, if necessary, revised or further detailed.

1.3 Communication and Coordination (SBW)

Work is already being carried out within different frameworks into components of wind modelling. The work on the different components that will be carried out within SBW will also take place on parallel tracks.

Central management of the activities is essential *within* the SBW project. The internal coordination is part of the standard project management.

A form of coordination and alignment is required to assimilate developments made within projects *outside* of SBW. This need not only ensues from considerations of efficiency, but also from the desire for long lasting knowledge management in respect of wind modelling and the formation of collaborations and knowledge alliances. It is also desirable to focus separate attention on exchanging with parties that work on wind modelling knowledge that is not directly related to flood protection in the Netherlands. See Annex 7 for a number of possibilities in this area.

There must be consultation with the involved parties to work out the concrete details of external coordination, to provide support for aspects such as the SBW communication plan. For the time being, the following activities are being considered for the exchange of plans, products, documents and news:

- The organisation of and participation in periodic consultation between various project leaders, in the form of a type of Wind Task Force, analogous to the Rivers Task Force, or a Consultative Council on Wind analogous to the Consultative Council on Waves.
- Organise regular workshops (comparable to the KNMI Hydra project and the Consultative Council on Waves)
- Set up and maintain a digital platform in the form of a website, ftp site and virtual project space.
- Provide PR in the form of a periodic (digital) newsletter,

Products: various: workshops, website, newsletter.
Status: in preparation, not yet started.
Schedule: yet to be determined.

2. WP2 Bring modelling up-to-date and make consistent (SBW)

Introduction

The objective of WP2 appears modest: to bring the current HBC wind models up-to-date and make them consistent. But this does not mean it is simply a minor stage that could perhaps be skipped:

- The current wind models form the basis and the reference point from where the wind models must be improved. This must be properly documented.
- Experience has shown us that it is complex material. There are very few people available that are familiar with the material and there is possibly nobody at all that is familiar with the totality of HBC wind modelling.
- In general, fundamental innovations in the methods of determining the HBC require long periods of acceptance, however interesting and appealing the innovations may be. Implementing fundamental innovations in HR2011 is therefore not feasible.

WP2 is specifically a SBW / HBC work package.

WP2 contains a multitude of activities. There is also a need for a division into fragments that can be carried out reasonably independently. There are different possible ways of doing this:

Division on the basis of content and area of expertise

Work package 2 could be divided on the basis of content as follows:

- Wind statistics
- Application in the Hydra philosophy: storm schematisation (statistics, time and space)
- Wind-water interaction

This in fact forms a division on the basis of a difference in the work area, where the focus of work and expertise is on:

- Wind statistics → KNMI: Processing and analysis of wind measurements
- Application in the Hydra philosophy → RWS: Statistics and Probability modelling in HBC (Hydra)
- Wind-water interaction → RWS: Modelling physics (water levels, waves, ...) in HBC

An advantage of this type of division is that the difference in work area focus provides a handle for the formation of teams, or the selection of market partners, that will work on the different components.
A disadvantage is that the delimitation is not as sharp. The topics are still quite closely interlinked, so they cannot simply be carried out as independent fragments.

Division on the basis of application area (water system):

Work package 2 could be divided as follows, on the basis of the intended applicable water system:

- Coast (North Sea, Estuaries, Wadden Sea)
- Lakes
- IJssel and Vecht Delta
- Tidal rivers
- Upper rivers

The advantage of this division is the clarity of delimitation. After all, by definition, each water system has its own implementation of the ‘Statistics and probability modelling’ component. It is therefore possible that the details of the stochastic function of wind are different for each water system.
However, the disadvantage of this division is that the separate approach to the water systems will obstruct the observation of similarities and, in particular, illogical differences in wind modelling between the water systems. And our objective is specifically to achieve a situation in which the differences between the wind models for the different water systems are minimised: the only differences that should be allowed to remain are the ones that can be properly substantiated.

Division on the basis of staging and interim products:

Work package 2 could be divided as follows, on the basis of staging and the types of activity and associated interim products:
- A *complete inventory* of the problems in the current wind models for the HBC determination: identification of inconsistencies and incorrect or outdated information.
- The *analysis* of the available literature and measurement data.
- The *updating* of the wind models for the determination of the HBC in Dutch water systems for the HR2011.

The advantage of this division is its connection with the intended products and the schedule. The disadvantage is that fragments have a very broad content.

Taking the above into account, we selected a composite division with the following hierarchy:

Stage \ Content \ Water system

This will be discussed in detail in the following sections. However, the division according to water system will not be explicitly documented here. See Annex 5 for an impression of current questions pertaining to wind modelling in the different water systems.

2.1 Inventory: Current wind modelling for the HBC (SBW)

Introduction

Inconsistencies are already known in many aspects of the wind models for the HBC. However, there is not yet a complete inventory of the present models and the differences between the different water systems or of the components within each water system. It is important to have an overview of this to obtain a good impression of the full extent of the consistency issues and of the focal points within them. This overview also provides the starting point and the fall-back option for updating the HR2011 (see section 2.3).

2.1.1 Wind statistics (SBW)

Statistics of speed and direction

To a large extent, this track of the WP2 involves an attempt at finally tying up the loose ends from the 1998-2003 KNMI Hydra project, to produce new formal wind statistics for the HBC. It is therefore essential to have a good knowledge of the products and remaining problems from the KNMI Hydra project (see http://www.knmi.nl/samenw/hydra/).

The Rijkoort-Weibull (RW) model from 1983

The essential characteristics of the original wind statistics in the RW model are:
- Point statistics based on multiple series of measurements of potential wind at KNMI measurement locations.
- The series of measurements are divided according to direction sector and season.
- Weibull distribution is fitted
- Corrections, such as for persistence, and simplifications are applied (smoothing).

Hydra-Wind-I

To avoid any confusion with the RWS Hydra models, from now on we will use 'Hydra-Wind-I' to denote the KNMI ‘Hydra’ project. Some of the conclusions from the Hydra-Wind-I project are:
- The methods from the 1983 RW model are not to be recommended.

- Hydra-Wind-I has developed a modified method that is in principle better. The software that has been developed, and the source code, is available on CD-ROM. This method has been applied to a number of KNMI stations. The results are available in the form of tables.
- However, there are reservations regarding the correctness and usability of these results for locations other than the measurement stations themselves, because during extrapolation the wind speed over a land station appears to become greater than for a coastal station. (The intersection of the lines is called the ‘curvature problem’, because the *shape* parameter differs between the two probability distributions.)
- There is no indication that the figures from the 1983 RW model are completely incorrect. This may be due to the relatively large effect of corrections that were applied.

A summary of the methods, with a reference to the available documentation, will suffice for the inventory of the current wind statistics. However, the following aspects do deserve further attention.

The wind statistics are not the same for all of the water systems, not even if they are based on the RW model. There can be differences in:

- The KNMI station that is used for reference.
- The definition and selection of the seasons that were considered, such as only the ‘winter-related six months’.
- Combined statistics were used for some water systems (Sea, Tidal rivers): the statistics from the combination of wind and seawater levels (and waves).
- In the case of Upper Rivers, a ‘design wind speed’ is based on a separate statistical analysis of measurement data from several KNMI stations.

Storm duration statistics

Until now, the storm duration has not been considered as a stochastic parameter in any water system[2] for the probability modelling used in the HBC determination. Despite this, in practice the storm duration can vary quite strongly, which can exert a considerable influence on the final loading on some water systems. It can therefore be important to choose a representative deterministic value for the storm duration. The inventory should provide an understanding of the statistical foundations of various choices in respect of the storm duration.

Products: report
Status: in SBW, not yet started.
There is an ongoing study in HBC into the different definitions in use for storm seasons, storm duration and storm initiation duration.

2.1.2 Schematisation of storm events: space, time and statistics (SBW)

The wind modelling within the HBC determination includes considerably more than just a table from the Hydra models that describe the wind statistics: each wind speed value should have an associated description of a representative storm in time and space. A description of this type involves a very large number of choices. The inventory must result in an overview of these choices and the associated foundations.

The following aspects of the storm description are important to the different water systems:

- How will the description of the storm event (in space, time and probability) be 'attached' to the wind speed and direction at a single location at the peak of the storm?
    - Which base station will be the reference location (stochastic function)?

[2] except for the Oosterschelde

    - How will the spatial variation in the wind statistics over the Netherlands be taken into account?
    - Which progression in wind speed over time will be adopted?
    - Which progression in wind direction over time (wind rotation) will be adopted?
- How does the Hydra post-processing deal with the possibility that the time of maximum loading on a water defence structure does not correspond with the peak of the storm?

Also focus attention on:
- A consistent interpretation of ‘potential wind speed’.
- The relationship between a) the progression of the wind speed over time, b) the progression of the storm surge at the coast and c) the progression of water level in accordance with the HBC and VTV.

Products: report
Status: No work is currently being carried out within SBW on this aspect.
Within the framework of the RWS project ‘Effects of Climate Change’, an overview will be formulated regarding the nature of the wind statistics files required by the different Hydra models.

2.1.3 Wind-water interaction: wind drag formulation (SBW)

The wind drag formulation is different for each model (water levels, waves, wind). The choice of formulation can even vary within a single water system if a combination of different models is used for a given phenomenon. This is an undesirable situation.

Wind modelling
The wind drag formulation determines the roughness of the water and is therefore important to the transformation of wind above land (where generally speaking measurements are available) to wind above water (where wind information is required to drive the water level and wave models).

Coordination between wind and wave models
The role of the wind drag formulation in wave models is often partially hidden. An important reference point in this is the question of which wave growth curve is produced by the wave model. There is also the question of if and how u_*-scaling should be applied.

Coordination between wind and water level models
In the Tidal River areas, the ultimate water levels at the toe of the dike are determined by three different models, each of which, either implicitly or explicitly, include their own choice of wind drag formulation.

Products: report
Status: not yet started

2.2 Analysis of measurement data and literature (SBW)

Introduction

Work in this component is primarily on aspects that proved during the inventory to be based on outdated data or to be insufficiently substantiated.

2.2.1 Updating wind statistics (SBW)

Hydra-Wind-II

As the goals of this part of WP2 correspond almost exactly with the Hydra-Wind-I project, we will call this project component Hydra-Wind-II.

Overcoming the curvature problem, in particular, is crucial to the successful completion of Hydra-Wind-II. Several hypotheses were formulated at the time for the possible causes of the difference in curvature between the statistics of land and coastal stations. However, there was no longer an opportunity (project framework) to test these hypotheses. SBW is currently setting up the appropriate project framework. New hypotheses also surfaced after the Hydra-Wind-I project had been completed, such as the one proposed by Marcel Bottema.

However, finding the cause or background to the curvature problem is only the first step. A method must then be found to deal with or eliminate this problem.

During Hydra-Wind-II, close contact and involvement is desirable from experts in relation to:
- Hydra-Wind-I
- Extreme value statistics and probability calculations (see the “SBW \ Boundary Conditions \ Statistics and probability modelling” project).
- The application of wind statistics in HBC (see section 2.1) and in the VNK / PCRing.
- Wind modelling in operational expectations: Hirlam-Downscaling, roughness map (WDIJ, Atlantis)
- Wind modelling in climate analyses: reanalysis and climate models (see WP4 ‘Tailor-made climate scenarios project’, and the dissertation by Henk van den Brink).
- Wind measurements (homogenisation) and hindcasts (see WP5).

It is evident that the KNMI plays an important executive role in this subproject. However, guidance from Deltares, RWS-WD, HKV and TNO is also desirable.

This is an extensive research component. It is therefore perhaps worthwhile introducing the following stages:
1. Address curvature problem in wind statistics
   a) Investigation by KNMI
   b) If necessary, obtain advice from abroad
2. Make analysis procedures from Hydra-Wind-I ready for use
   a) Homogenise the series of measurements
   b) Statistical analysis of time series at measurement locations
   c) Method for determining the point statistics at non-measurement locations
3. Statistical analysis of storm duration
4. Perform analysis and checks
5. Publish results

Products:
* analysis of curvature problem: report
* updated series of wind measurements at KNMI stations: data with documentation
* method of processing raw series of measurements at KNMI measurement stations into statistics of potential wind at the relevant locations: software with documentation
* point statistics of potential wind at all KNMI measurement locations with a sufficiently extensive series of measurements: tables with documentation
* method of determining the point statistics at other arbitrary locations on land or water: software with documentation
* description of the statistics of the storm duration and a recommendation for a representative choice in the event of a deterministic application: report

	* an update of the “Wind climate in the Netherlands” from 1983: final report or book
Status:	KNMI is currently working on the analysis of the curvature problem; this problem has been submitted to the Risø in Denmark for an exploratory investigation.
Schedule:	The diagnosis of the curvature problem must be completed by the autumn of 2007.

2.2.2 Schematisation of storm events (SBW)

For the time being, the ‘ideal’ schematisation of storm events that can be used to steer the water level and wave models will retain a relatively highly pragmatic character in the current wind models. The sensitivity of the end result must be taken into account when searching for optimum choices in respect of the aspects contained in section 2.1.2. The analysis of this sensitivity therefore also forms an important part of this research component.

Naturally, the reality level of the storm event schemas is also important, as are the documented foundations and the required uniformity for the different water systems.

Products:	report
Status:	not yet started

2.2.3 Wind-water interaction: wind drag formulation (SBW)

In 2003, the KNMI, RIKZ and RIZA partnership worked on a working document ‘wind drag formulation’ with the goal of arriving at a uniform choice. However, this was not completed because the funding (SBW) was stopped. We propose that this document is now completed.

Products:	report
Status:	there are building blocks available for the report on the possibility of a uniform choice for the wind drag formulation.
Schedule:	RWS-WD & Deltares & KNMI will complete the document in 2007.

2.3 Updating the wind models for HR2011 (SBW)

It is quite possible that not all the problems for all the water systems can be resolved for the HR2011. A balanced package of modifications will have to be put together in the form of a recommendation for the HR2011 for the different water systems. (It is possible that for certain components the decision will be made to fall back on the wind models used in the HR2006).

The advice must be specified for each water system. Consideration can also be given to fact that the urgency of the modification or recommendation is not equal for all water systems.

A recommendation must also be formulated for the HR2016 in respect of a balance between:
- investment in resolving the other problems in the current systems (WP2) and
- investments in innovation (WP3)

Products:	Recommended wind models for use in determining the HR2011 for the different water systems: report.
Status:	not yet started

3. WP3 Modelling innovation

Introduction

It is known that the current wind models have several fundamental shortcomings and problems. The goal of WP3 is to develop and implement new knowledge to resolve these shortcomings and problems. In part because of the period required for the acceptance of new methods, this work package is a long term project.

For the time being, WP3 is not specifically a SBW / HBC work package. Some of the developments can be used from projects that are running parallel to SBW / HBC. However it is worthwhile within SBW to perform an investigation into the possibilities for innovation in wind modelling for the HBC. In addition, SBW can then start working on partial aspects.

3.1 Investigation of innovation possibilities (SBW)

It would be worthwhile to make a directed action of an investigation into the possibilities of innovation in the wind modelling for the HBC. The product (a report) can be a ‘living’ document and a stepping stone for new projects and collaborations. During the investigation it will be possible to distinguish different grades of innovation, in other words: different levels of deviation from the current models. The following sections will provide a number of examples of work areas that contain possibilities for innovation. The description is often presented as a series of points.

3.2 New storm schematisations in the RW model

Attribute renewal:

- Does use a basis of point statistics, but with a different application: a different storm schematisation in space and time.

Current method:

Parameterise storm: peak speeds and direction during peak at reference location. A storm schematisation will be linked to these parameters:

- interval of time:
    - speed: storm duration, leading edge, peak duration, following edge?
    - direction: rotation
- spatial pattern
    - speed of spatial pattern on the basis of equal probability of exceedance?
    - land-water transition?
    - synchronous progress {U,R} over time or a moving pattern?

Elaboration directions for innovation:

- Define storm progression as extra stochastic parameter?
- Land-water transformation via macro level instead of via meso level (with Downscaling role)?
- Moving spatial pattern instead of spatially synchronous progression (step up to a 'storm generator')?

3.3 New storm statistics

Attribute renewal:

- No longer use point statistics as the basis (basic stochastic parameter), but instead use measurement series or statistics of wind fields in space and time

Elaboration directions for innovation:

- Approach via climatic model (in accordance to Van den Brink): investigations using weather models in hindcast mode or in climate mode
- Approach via parameterisation of wind fields (can also be performed in cooperation with approach via climatic model), for example:
    - "storm generator" (in accordance with Bijl),
    - Approach via EOF (JIP)

Other focal points of storm statistics:

- Twin storms: analyse statistics and importance to protection.
  There are indications: a) that twin storms occur suspiciously often; b) twin storms are important in relation to flood protection and; c) they should be included in the considerations and/or the wind modelling. However, this must all first be verified in more detail.
- Correlation between wind and extreme river discharges (see section 2.1.2)
- Correlation between wind and seiches (see section 2.1.2)

3.4 New wind-water interaction

Wind-water interaction, or wind drag, is an important aspect, but progress in respect of both knowledge and modelling is slow: it is a complex topic. Fundamental research in this area is outside the SBW framework. However, it is useful to assess the available knowledge and monitor ongoing research. This could include the following topics:

The bilateral aspect of interaction between wind and water

What must we and can we[3] do with the bilateral aspect of the interaction between wind and water? There is a relationship between wind drag and wave characteristics, but if the wave characteristics display large spatial variation, which characteristics do we use in the drag calculations? Does the increase in accuracy outweigh the complexity it introduces?

Wind drag at extreme wind speeds

Is there is a maximum drag or even a decrease with increasing wind speed? (see the Makin publications). Is this maximum relevant to the wind speeds in the Dutch situations that are being studied? If so, can it also be applied in a practical manner?

Water levels and waves during extreme wind speeds

The role of aspects such as spray, waves disrupted by wind and extreme white-capping.

- What is ‘the’ water level?
- Can we still talk of waves, in the normal sense?
- What does this mean to the loading on the water defences by the ‘waves’?

[3] pragmatic!

4. WP4 Climate change

Introduction

An important step forwards has been made since 2006 by focusing attention on wind in the climate scenarios. Unfortunately the resulting information regarding the (expected changes in) the wind climate does not provide us with enough of a foundation to determine the outlook for flood protection in the Netherlands. The uncertainties in the determination of the *current* wind climate within the framework of the HBC determination (in this case an extreme value statistic) are so great that for the time being it is almost impossible, and of is no value, to try and quantify *changes* in this climate.

It therefore appears that it is still too early to start working on the aspect of wind climate change. However, this is only partly true. This is because it is important to have the set of computation instruments ready when realistic wind climate change scenarios become available. In addition, this set of instruments could be used in advance for investigations within the framework of policy preparation (What if? studies), for which there is already a need. The exact information needs will only become clear after the set of computation instruments has been crystallised.

In short, it is important to perform work now on topics such as:
- What is meant by a scenario such as “take into account 10% more wind”? Or, more broadly formulated: which wind parameters do we need in climate scenarios?
  This question is already more than trivial in the current method (WP2), and this is only likely to increase in the, as yet unknown, innovative method in WP3.
- In the Hydra philosophy, a change in the wind climate can be processed in the statistics files. However, this will be difficult because the files are less than clear and, because of differences in the methods, can be different for each water system (see WP2).

Strictly speaking, studies into climate change are not part of the work associated with the HBC, and therefore not with the SBW, even if the SBW plan of action does include some latitude for this.

Work is being performed outside the SBW project to map out wind climate change and to take it into account. As there are important connections with work on the wind modelling being performed within SBW, this will be examined further.

4.1 Supervision of KNMI climate scenarios

<u>A general outline of the supervision of the KNMI climate scenarios</u>
The RWS-WD / Deltares studies and comments on interim communications on the KNMI findings and wishes to be prepared for any sensitive implications of climate scenarios on policy.

Products: KNMI report: general climate scenarios
Status: 2006 edition completed

<u>Supervision of tailor-made KNMI climate scenarios</u>
RWS-WD / Deltares steers the KNMI, with a focus on specific climate parameters such as the statistics of extreme wind.

Products: KNMI report: climate scenario for extreme wind
Status: being implemented

4.2 Methods and instruments for computing the implications of wind climate scenarios

It is possible to distinguish the following activities:

<u>Streamline the modification of wind statistic files for the Hydra models</u>
There is a strong relationship with the Hydra family and the manipulation of the other statistics tables. There is also a strong relationship with the required wind model unification (WP2).

Products: report
Status: being implemented within SBW

<u>Streamlining the implication calculations</u>
A connection can be made here with the 'Hydrascope', as implemented within the framework of the policy acceptance process of the HR2006.

Products: report
Status: being implemented outside SBW

<u>Map out the implications of wind climate scenarios</u>
This includes the actual implementation of, and reporting on, the implementation calculations.

Products: report
Status: not yet started

5. WP5 Wind measurements (SBW)

5.1 Define the need for wind measurement information (SBW)

Introduction

All the important choices in respect of the wind modelling should be validated using measurements. However, in practice, it appears the validation of different aspects is very limited.

It is preferable when formulating the measurement needs to also start determining how the measurement data will be processed and analysed. This can provide an understanding of the additional requirements that will have to be placed on the measurement data.

5.1.1 Measurements for hindcasts of water levels and waves (SBW)

Wind fields in time and space are required to be able to perform hindcasts of water levels and waves in the Wadden Sea. These can be determined using weather models such as the HiRLAM-Downscaling combination. A set of well chosen wind measurement points can provide an important contribution to this in the form of validation and, if required, modification of the weather model results.

A detailed description of the measurement needs has already been worked out for this type of wind measurement in the Wadden Sea. This has placed the emphasis on the one hand on the closeness of the highest concentration of wave measurement buoys and on the other hand on obtaining an understanding of the effect of land-water transitions. (See the memo on the wind measurement needs by Annette Kieftenburg and Hans de Waal.)

5.1.2 Measurements for use in the statistics (SBW)

Multiple series of consecutive measurements, that are as long as possible, are required to be able to obtain extreme value statistics. The longest series of measurements are available from the KNMI, which are being added to all the time. However, this does primarily involve measurements at land stations. It is precisely with this type of station that changes have occurred over the years in the measurement method and/or in the roughness of the area surrounding the measurement station. The measurement series must therefore be homogenised. This means that the measurements must be converted to a fictitious wind for a standard roughness of the surrounding area: the potential wind. However, this certainly does not resolve all the interpretation problems, and new interpretation problems may even be introduced.

The important items are: measurement duration, continuity, measurement location (land or water), homogenisation and interpretation (including atmospheric stability).

5.1.3 Measurements for use in the physics: patterns in space (and time) (SBW)

Spatial variation in the wind measurements can be present as a consequence of:
- Spatial variation in the weather system.
- Spatial variation in the roughness of the area, including land-water transitions.

The important items are: density of the spatial measurement network, distribution of measurement locations over land and water, homogeneity and interpretation, including area information (roughness map).

5.1.4 Measurements for use in the physics: patterns in time (and space) (SBW)

Changes that result from two trends can be measured over time for each measurement location:
- A spatially variable weather system moves over time in relation to the measurement station.
- A spatially variable weather system changes internally over time.

Normally both trends will occur simultaneously. The first trend is probably more important to be able to understand the change in wind direction over time. The second trend is also important to be able to understand the wind speed change over time.

Changes over time will not run synchronously for the different measurement locations. However, the shape of the time-related change for each storm can exhibit major similarities at different measurement locations.

The important items are: continuity, sampling and averaging over time, spatial coverage, storm duration and direction change.

5.1.5 Measurements for use in the physics: wind-water interaction (SBW)

The wind drag is an important aspect of the wind-water interaction. Unfortunately it is difficult to measurement wind drag directly and so an indirect form of measurement is generally necessary. However, during the interpretation of the indirect measurements, assumptions are often required that are difficult to properly verify.

The important items are: measurement location above water, wind speed profile, turbulence, atmospheric stability (air and water temperatures), wind drag, waves, high wind speeds and interpretation.

5.2 Collection of wind measurement information (SBW)

5.2.1 Understand, use and coordinate ongoing measurements (SBW)

To accommodate the wind measurement needs, it is probably not necessary to start a new measurement campaign for each requirement. A determination must first be made of the wind measurement campaigns that are currently ongoing outside of the SBW framework and of how SBW could use the ensuing measurement data. There is a strong relationship here with the ‘coordination and alignment’ component in WP1.

A number of principles for the ongoing wind measurements are given below.

KNMI
- standard weather stations (land, coast, water - Cabauw profile)
- other wind measurements

RWS monitoring measurements
- Wadden Sea (SBW)
- IJsselmeer (IJG wave measurements & WDIJ set of instruments for the innovation model)

- Houtribdijk (KNMI / IJG)
- Zeeland
- Wind measurements at different (shipping) engineering structures

Other wind measurements in the Netherlands
- Wind parks on water and land such as the Egmond wind park and wind parks around the IJsselmeer.
- ECN

International
- Risø wind measurements

5.2.2 New measurements: set-up and utilisation (SBW)

Setting up specific measurement programmes for SBW are naturally part of the SBW project. The detailed formulation of the measurement requirements and the analysis of the measurement results must be carried out within 'SBW \ Limiting Conditions \ Wind modelling'. The actual measurements are carried out within 'SBW \ Measurement'.

Several possible tracks are presented below:
- Wadden Sea (SBW – monitoring measurements)
- IJsselmeer (SBW – process measurements / cooperation with RWS-IJG)
- China: Tai Hu (cooperation with RWS-IJG)

5.3 Utilisation of wind measurements (SBW)

5.3.1 Processing the wind measurements (SBW)

Introduction

The processing of the measurement data is comprised in part of mathematical processing on the basis of selected definitions, but also in part of the application of a given wind model.

Examples of mathematical operations on the basis of selected definitions are:
- Application of calibration function
- Taking the average over a given period for use in the selected definition of 'average wind per hour'.

Examples of the application of a given wind model are:
- Homogenisation time series (point measurements)
- Expansion of point measurements to wind fields in space and time (= storm hindcasts)

In particular, the application of a wind model during the aggregation of wind measurements has not been unambiguously defined: models can change on the basis of changing insights.

There are important differences between the wind models for the aggregation of wind measurement information on the one hand and wind modelling for the HBC on the other. This is because the wind modelling for the aggregation of wind measurement information can use additional measurement information such as the temperature or air pressure. This type of additional information is not available for 'HBC storms'.

5.3.2 Interpretation and analysis of wind measurements (SBW)

The interpretation and analysis of the wind measurements has yet to be worked out in detail. This will be carried out in part while formulating the need for measurements. The actual implementation of the analysis is of course in part dependent on useable information becoming available.

Project Plan

SBW \ Boundary Conditions \ Wind Modelling

Annexes

Author : Hans de Waal
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Status : draft
As this version is intended for the InfoRouter and others, financial data has been omitted.

Contents

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Annex 2: Text related to wind modelling in SBW Plan
Annex 3: The model chain
Annex 4: The Hydra philosophy
Annex 5: Focal points of current wind modelling in the different water systems
Annex 6: Wind climate changes
Annex 7: Common ground with parties abroad and/or related areas of expertise

Annex 1: References

Bottema, M., 2005. Knelpunten windmodellering voor hydraulische randvoorwaarden. Concept-memo, intern RIZA, 24 januari 2005. Opgenomen als bijlage A in: Bottema, M., 2006. Gedrag van het SWAN-golfmodel mét en zonder verbeterde diepwaterfysica, met nadruk op korte strijklengtes. Rijkswaterstaat RIZA, RIZA werkdocument 2006.057x, 2006.

Brink, H.W. van den, Extreme winds and sea-surges in climate models. Utrecht University, thesis, 2005.

Geerse, C.P.M., 1999. De interpretatie van het Rijkoort Weibull model. RIZA rapport 99.048.

Haskoning, 2006. Sterkte & Belastingen Waterkeringen. Projectplan 2007-2011. Royal Haskoning, 29 september 2006.

Lammers, I.B.M., Kok. M., 2006. belang van windmodellering voor Hydraulische Randvoorwaarden. Achtergrondrapport. HKV Lijn in Water, PR1072.10, juni 2006.

Ministerie van Verkeer en Waterstaat, 2001. Hydraulische Randvoorwaarden 2001, voor het toetsen van primaire waterkeringen. Ministerie van Verkeer en Waterstaat, Directoraat-Generaal Rijkswaterstaat, RIKZ, DWW, RIZA, december 2001.

Ministerie van Verkeer en Waterstaat, 2004. De veiligheid van de primaire waterkeringen in Nederland. Voorschrift toetsen op veiligheid voor de tweede ronde, 2001-2006. Januari 2004.

Rijkoort, P.J., 1983. A compound Weibull model for the description of surface wind velocity distributions. Wetenschappelijk rapport / Scientific report W.R. 83-13. KNMI.

Smits, A., Klein Tank, A.M.G., Können, G.P., 2005. Trends in storminess over the Netherlands, 1962-2002. International Journal of Climatology, 25: 1331-1344.

Verkaik, J.W., Smits, A., Ettema, J., 2003. KNMI-HYDRA project, Faserapport 16: Naar een nieuwe extreme waardenstatistiek van de wind in Nederland. KNMI, september 2003.

Waal, J.P. de, 2003. Windmodellering voor bepaling van waterstanden en golven. Een analyse van de bouwstenen. Rijkswaterstaat RIZA, RIZA werkdocument 2003.118x, juli 2003.

Wieringa, J, en Rijkoort, P.J., 1983. Windklimaat van Nederland. Klimaat van Nederland, 2. KNMI.

Website of the KNMI-Hydra-I project: http://www.knmi.nl/samenw/hydra/

Annex 2: Text related to wind modelling in SBW Plan

Text in SBW Plan of action - main text

[…] research questions have been formulated for the wind modelling issue. The effect of wind on the water system is indicative of the loading on much of the Dutch dikes. The TAW has a number of reservations regarding the wind modelling methods that have been used until now.

Long term KNMI research that was initiated on the basis of TAW advice has resulted in insufficiently consistent, and therefore insufficiently explainable, results.
These questions are:

- How do we translate the extreme KNMI statistics available for wind above land to the desired extreme statistics related to wind at an arbitrary location above water?
- How do we upgrade the current point statistics to storm field statistics?
- How do we model the air-water-energy transfer and the corresponding water roughness?
- What is the effect of climate change on wind: fewer smaller storms, but more super storms? Does the storm duration change?
- Is there a need for additional wind measurements (additional wind masts)?

The results contribute towards the assessment of over 1000 km of primary water defences divided over 30 dike rings and will be included in the HBC.

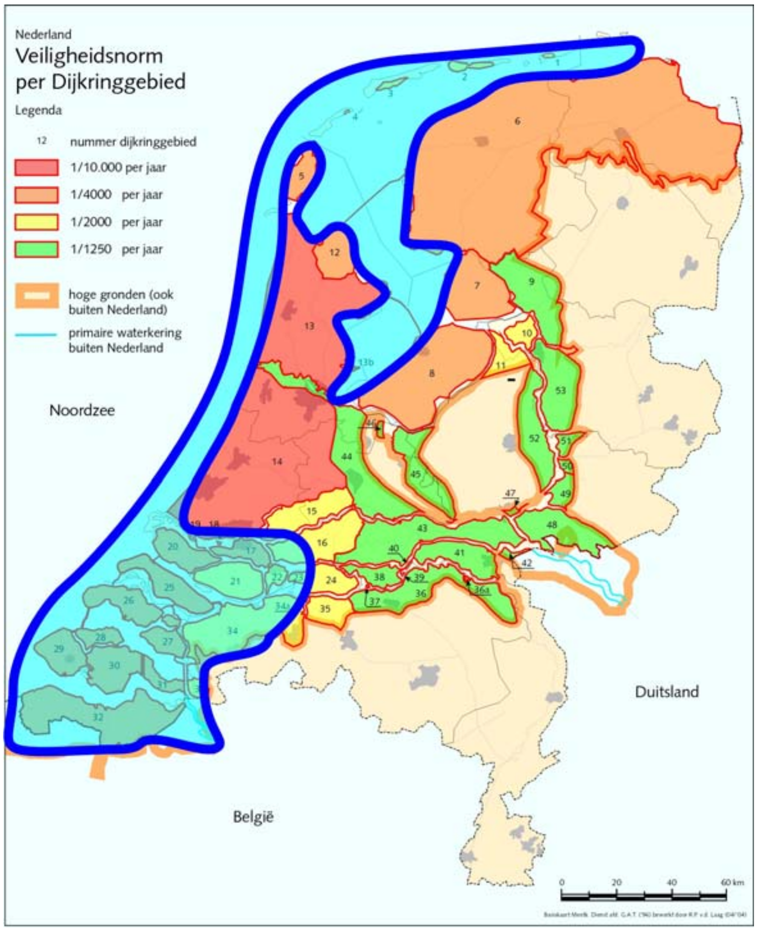

Figure 1 Relevant locations of wind and wave statistics.

Translation list	
NL	UK
Nederland	The Netherlands
Veiligheidsnorm per dijkringgebied	Safety standard per dike ring area
Legende	Key
nummer dijkringgebied	dike ring area number
1/100.000 per jaar	1/100,000 per year
hoge gronden (uit buiten Nederland)	high ground (outside the Netherlands)
primaire waterkeringen buiten Nederland	primary water defences outside the Netherlands
Noordzee	North Sea
België	Belgium
Duitsland	Germany

Text in SBW Plan of action - annex

Wind modelling

1. Title of subproject	**Wind modelling**
2. Name of subproject leader	E.H. Chbab, J.P. de Waal (RWS RIZA)
3. SBW subproject	Hydraulic Boundary Conditions
4. Participating organisations	RWS DWW, RWS RIKZ, RWS RIZA, KNM
5. Involved water boards	All water boards responsible for primary water defences in the Netherlands
6. Relationship to other projects	HBC (Hydra programmes), VTV and VNK (PC Ring)
7. Estimated costs (k€)	
8. Reason or background	A problem analysis performed recently by HKV showed that: • The effect of wind on the water system is indicative of the loading on much of the dikes in the Nethelands. • The TAW has several reservations regarding the wind modelling methods used until now. • Long term KNMI research that was initiated on the basis of TAW advice has resulted in insufficiently consistent, and insufficiently explainable, results. • Existing wind knowledge is not adequately applied. • And there are crucial knowledge gaps in four areas. • Financial savings, in terms of avoided damages or savings on dike reinforcements, are expected in the order of 0.3 to 3 billion euros. All this argues strongly for a stronger focus on the aspect of 'wind'.
9. Purpose of the project	In compliance with the general SBW objective of "improving the methods for determining the HBC (Hydraulic Boundary Conditions, including waves), including in extreme conditions. This must take into account the fact that wind – via wind set-up and wave generation – is the indicative loading for certainly half of the Dutch dikes, and the fact that knowledge about the modelling of wind (extremes) has diverse significant gaps.
10. Scope:	Large There are substantial uncertainties in respect of wind, both in absolute terms as well as in their effect on the HBC. Wind is not important just to a single region, but for *most* of the major water systems in the Netherlands. Good wind modelling is not only important to the HBC but also for operational warnings, such as RWS (hydraulic) and the KNMI (the wind itself).
11. Intended advantages • Political • Economic • Technical	Political: In the current situation, wind related components of the HBC can easily be undermined by experts (regards content) and non-experts (regarding consistency). In addition, there is a considerable risk of the dike design being too high or too low. This project will resolve the first aspect and reduce the second. Economic: Savings of 300-3000 million euros (see above) Technical: Arbitrary assumptions in respect of wind will be required less frequently, which will help achieve a uniform HBC determination as well as cooperation and support from the experts. Sharing wind knowledge will also help both meteorologists and hydraulic engineers to progress (cross-pollination).

	Other: The results will contribute towards an improved understanding that can be used in the assessment of approximately 1000 km of water defences spread over roughly 30 different dike rings.
12. Reservations and risks	Working on wind, both in respect of measurements and modelling, involves working at the boundaries of our knowledge and demonstrates that nature does not always adhere to widely accepted and well founded theories. As a result, well-executed research into wind does not provide a 100% guaranty of applicable results.
13. Specific questions that must be answered during the project:	How do we translate the extreme KNMI statistics available for wind above land to the desired extreme statistics related to wind at an arbitrary location above water? • Model differences and uncertainties in spatial wind transformation up to 30%. • KNMI HYDRA project: coastal wind extremes lower than inland: physically plausible. How do we upgrade the current point statistics to storm field statistics? Statistics? • Current storm durations are uncertain and not well-founded but certainly crucial at hydraulic 'bottlenecks': - storm durations that are too short will result in dikes that are too low. • Wind direction developments are very important (New Orleans). • Storm dimensions and speed of travel are very important (a small storm will suffice on the IJsselmeer but the North Sea requires storm paths hundreds of kilometres long). How do we model the air-water-energy transfer and the corresponding water *roughness*? • This roughness is crucial to wind, water level and wave modelling (up to 20% of the effect on the dike height comes from roughness uncertainty, almost as much as the effect of wind uncertainty). • Additional uncertainties related to hurricane research: in the case of hurricane winds, roughness reduces considerably into: more wind, less waves + wind set-up. • Roughness is greater in shallow water but the above effect may appear earlier (shallow water -> steeper waves -> wave tops blown off sooner). What is the effect of climate change on wind: fewer smaller storms, but more super storms? • Consequences of extreme winds are statistically very uncertain. • The statistics of changing storm direction has a major effect, but frequently only has a limited effect on the wind direction sector for dikes and other areas! Need for wind measurements (extra wind masts).
14. Products that must be produced:	1a) Report with explanation of inconsistencies in KNMI-HYDRA results, using an analysis of 32 years of measurements made at various heights on the KNMI measuring mast in Cabauw. 1b) On the basis of 1a): Robust and consistent statistical methods for determining wind extremes. 1c) A method for spatial wind transformations, in particular from land to water, validated for normal wind and storms. 2a) Improved point-based storm statistics (storm progression, storm duration, direction progression), divided according to location and region. 2b) Storm field generator for the generation of extreme storm fields and the associated statistics. 3a) Improved model for the aerodynamic roughness of water, if necessary supplemented with a model for aerodynamics for the case of vegetation flattened by wind on land. Roughness on land in the case of extreme wind. 4a) Sensitivity studies on Dutch water systems: which types of wind climate change are critical to the dikes, and which types are not. 4b) Case studies on the basis of actual climate scenarios and climate model time series in addition to and in support of the above: 5) Documented and validated wind and wind drag measurements over open water with wind set-up and wind generated waves, to be obtained from existing measurement campaigns if available, and campaigns that have yet to be initiated, both inside and outside of SBW at home and abroad. 6) Report necessary wind measurements.
15. Completion date:	
16. Status at the end of 2006	RIZA problem analysis, performed by HKV.
17. Planning:	(set up in compliance with attached example)
18. Quality assurance:	• In compliance with SBW quality assurance system. • Sounding board group meetings with experts. • Hydra-like workshops, 2 twice per year • National and international presentations (ENW, congresses and conferences).
19. Communication and PR details:	In compliance with SBW communication plan. Workshops and brochures. Symposia, congresses and conferences.
20. Other remarks	The gap between meteorologists and the water boards was and is wide, which has resulted in a sub-optimum development and use of the knowledge related to (extreme) winds. Activities to reduce this gap (RWS and KNMI = a single Ministry for Transport, Public Works and Water Management) are highly desirable.

Annex 3: The model chain

The following diagram shows the general form of the model chain, as used in the determination of the HBC for the different water systems. For purposes of the overview, information blocks such as area information (water system contours, bottom levels) have been omitted. The same applies to special stochastic parameters such as storm surge barriers.

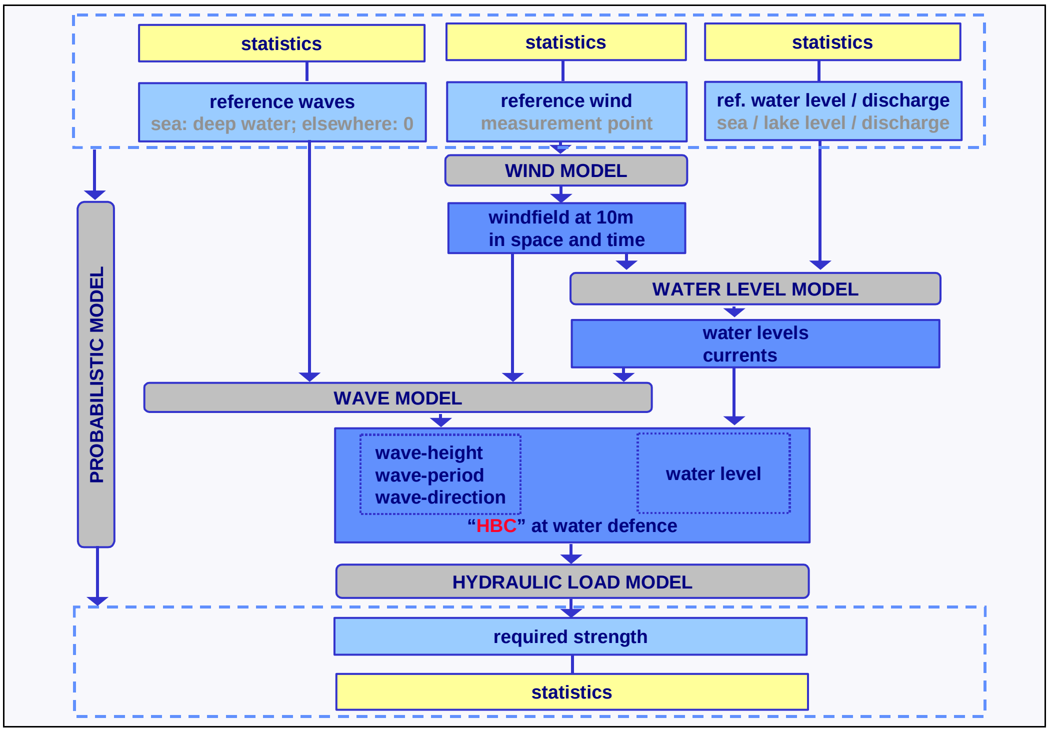

Figure 1. Flow diagram with the explicit role of the probabilistic modelling.

Annex 4: The Hydra philosophy

Hydra is the family name for a group of computer models that are designed to be an aid to the water boards during the use of the HBC for the assessment of the water defence structures. This is because Hydra determines the extreme value statistics (exceedance probability) of the hydraulic loading on a dike section. During the assessment, the hydraulic loading at the standard frequency of the relevant dike ring is compared to the existing strength of the defence structure.

Hydra was developed in particular for water defences for which *combinations* of threats are important. The water defence structure near Kampen is a relatively simple example of such a water defence structure. This water defence structure is threatened either by: a) a very high discharge from the IJssel in combination with a moderate wind (limited amount of wind set-up from the IJsselmeer) or by; b) a moderate IJssel discharge in combination with a heavy north-westerly storm (major wind set-up from the IJsselmeer)… and of course all the combinations in between!

Each water system has its own characteristic combination of threats. This is why until now a separate Hydra has been made for each water system. The area of application is denoted by a suffix to the Hydra, such as Hydra-M for the IJssel*meer* area (where M = Meer = lake in English). Until now, a separate Hydra has not been required for the 'upper rivers' water system because here a single threat is much more important than all the others: the river discharge.

Model	**Area**
Hydra-K	Coast (NL = Kust): fresh waters
Hydra-M (and Hydra-Q)	Lakes (NL = Meren): IJsselmeer; Markermeer
Hydra-B	Tidal rivers (NL = Benedenrivieren)
Hydra-VIJ	Vecht delta and IJssel delta

Table 1. Overview of important members of the Hydra family

One of the first steps in the Hydra philosophy is to further specify the threats in the form of stochastic parameters. A 'wind' threat can for example be characterised by the two stochastic parameters of wind speed and wind direction. But for a specific water system it may for example be meaningful to consider the storm duration as the third stochastic parameter for wind. This is how the threats to each water system are translated into concrete stochastic parameters.

Hydra structure

The following diagram shows in the basic organisation of the Hydra models.

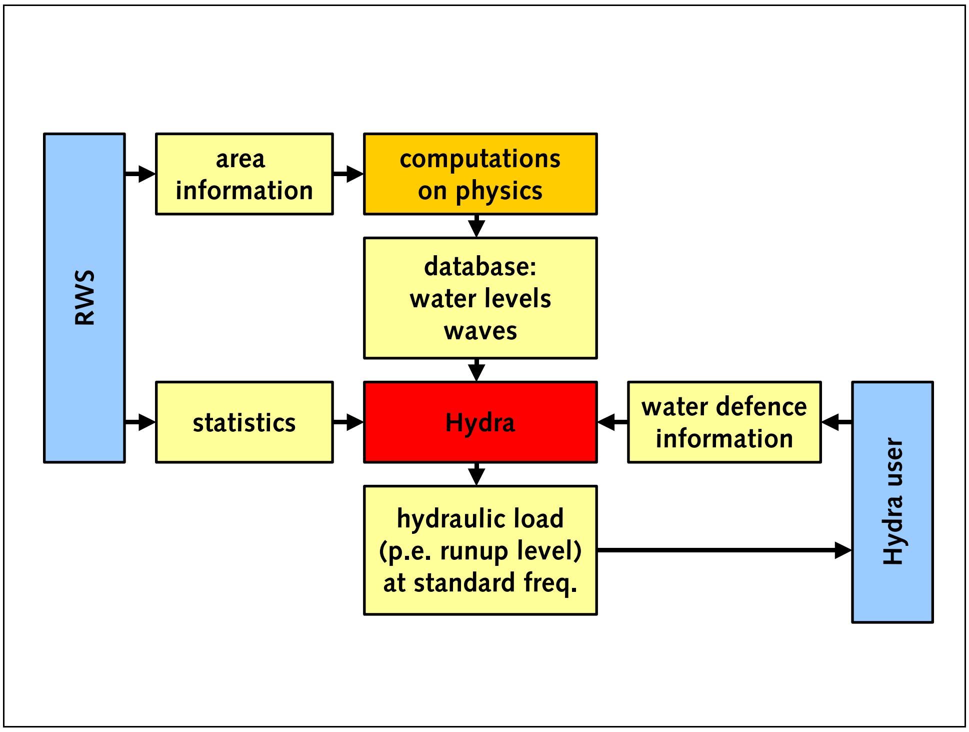

Figure 2. Basic organisation of the Hydra philosophy

The different components of the diagram will be discussed – either individually or clustered – in brief below.

Area information and Statistics

RWS supplies the Area information and the Statistics in relation to the stochastic parameters such as river discharge and wind[1]. The Area information is processed in schematisations for computational models of water levels and waves, such as Waqua, Sobek, Hiswa and Swan. Each model is then calibrated.

The choice of this data is very critical to the five-year determination of the HBC. The thermometer concept is adopted when performing this task. However, in the case of policy studies, RWS can use this data to make adjustments to the model: in a project like 'Space for the River', RWS can change the area geometry and bottom levels. And in the case of long term climate scenarios, RWS can adjust the statistical data of the river discharge, for example.

Production runs and Database of water levels and waves

RWS is also the architect behind the Production runs of computations on physics, in which the water levels and waves are calculated for a large number of combinations of values of the stochastic parameters. In particular, calculations are made for very extreme combinations of threats. Water level models such as Waqua and Sobek and wave models such as Bretschneider, Hiswa and Swan are used for the production runs. The water levels and waves are determined for a large number of 'implementation locations' along the primary water defence structures around the water system. All this data is stored in a large database of water levels and waves.

[1] Wind-based Information is obtained from the KNMI.

Intermezzo: the selection of a single representative point in time

A scenario is computed, with an assumed progression in the boundary conditions over time, for each individual production run. These scenarios are also called events. The calculated water levels and waves will vary per event and per location over time. As the calculated duration per event, number of events and number of implementation locations are all large, the production runs produce a overwhelming amount of information. If this information were to be placed in the Hydra databases, it would result in extremely large databases and long computation times because of the searches performed in these large databases. This is an undesirable situation.

It has therefore been decided in the Hydra philosophy to omit the information about the progression over time: for each event, the information about water levels and waves of just a single point in time within the event is stored in the Hydra database for each location. The point in time is the moment within the event when the water level is at its maximum at the location being considered. This time can be different for each location. The spatial pattern of the calculated representative conditions is therefore generally not representative for a spatial pattern at a single point in time within the event.

Formulated more generally: the information calculated in the production runs on the progression of the water levels and waves over time is lost in the current Hydra philosophy.

This database only contains physics and not any statistical information. The database can only be applied by performing new production runs. This can be a rather substantial task and demands very precise work, in particular for the HBC determination. A faster and less precise method is required for policy studies and sensitivity research. For this reason, smaller databases are used for these types of study (such as for ‘Special Hydra-B’) and simplified models are used for production runs on physics.

Dike information

The Hydra user – primarily the water boards – selects an implementation location in their water system and provides the dike information. This is information regarding the water defences present at this location such as the dike profile, the dike orientation and the required exceedance frequency.

RWS does not posses this dike information. In policy studies and sensitivity analyses, RWS often uses a particular standard dike profile or a selection of dike profiles that were supplied by the water boards and provinces for a specific purpose.

Hydra computational centre and output

Hydra reads the database to obtain the water level and wave data for the selected location. Hydra uses a run-up module and the supplied dike information to translate all combinations of water level and wave into loading levels for the dike. The Hydra user can make a choice from many types of loading, including ‘only water level’ or ‘sum of water level and wave run up’. The probability-based computation centre of Hydra combines the loading levels with the associated statistical information and ultimately determines the loading level at the requested frequency.

Future outlook

The Hydra family clearly fulfils a need and therefore has a future in the sector of water defences. The current needs from this area of application are still diverse: continuity and uniformity are key to the HBC determination, while the focus is on flexibility and speed for policy and sensitivity studies. Good cooperation between the involved parties and the intelligent use of common Hydra building blocks will mean that to an increasing extent all these needs will be better fulfilled.

Annex 5: Focal points of current wind modelling in the different water systems

Several focal points for each water system will be specified below that need to be further elucidated in WP2. However, some questions may not be dealt with until WP3.

Coast (Hydra-K)

- How realistic is it, in a physical sense, to scale-up observed storms?
- On the basis of observed combinations, there only appears to be an accepted statistical correlation between wind on the one hand and water levels and waves on the other. So, what precisely is happening here? Is no use being made of the physical relationship between wind on the one hand and water levels and waves on the other? If not, then how can you use this method to process possible future wind climate change? Or new insights into the statistics of extreme wind, such as Henk van den Brink's super storms?

Lakes (Hydra-M and Hydra-Q)

The Hydra approach used for lakes (IJsselmeer and Markermeer, including their outer reaches) uses three stochastic parameters:
- Lake level (degree to which the water system is filled)
- Wind direction
- Wind speed

Wind is the most important stochastic parameter for most defence structures. The wind determines both the water levels (as the result of an internally sloping water level and/or wind set-up and set-down) and the waves (as a result of internal increase, from zero). As the lakes are extensive and relatively shallow (around 5 m), the wind set-up is relatively large. In extreme situations, the wave increase is depth limited in the form of the wave growth limit.

All *wind directions* are important as the water systems are entirely surrounded by defence structures. A differentiation of the wind statistics into *seasons* is important because the management of the lake water level, and therefore the lake water level statistics, is dependent on the season[2].

The water systems next to the large expanses of open water that make up the lakes respond very quickly to changes in the wind conditions, but in the smaller outer reaches (Ketelmeer ... Zwartemeer[3], Gooimeer … Eemmeer) the reaction speed is reduced and the *storm duration* becomes important.

In some short outer reaches of the IJsselmeer (Lemmer, Houtrib Noord) the progressive changes in water level can occasionally exhibit short, sharp *jumps* or *oscillations*. There have already been observations of peak to trough values of over one metre. There is a possible relationship between rapid changes in the weather system, such as a passing front, but the exact mechanism behind these water level fluctuations has not yet been determined. The presence of a 'cellular structure' in the weather system – the mechanism behind the seiches in the Europort area (see De Jong) – does not appear to be the cause.

Almost all aspects of wind modelling, and their internal problems, are important to this water system.

Tidal rivers (Hydra-B)

[2] There are currently only two seasons in respect of the lake water level management, but there is a need for additional possible variations, in part because of ecological considerations.
[3] The inflatable weir at Ramspol is used during extreme conditions, which in fact cuts off the Zwartemeer from the Ketelmeer.

- Wind modelling is contained within many model components that underlie the HBC determination, and they are not always consistent with each other.
- The storm growth duration, which results from the storm duration, is a sensitive item that must be figured out in the short term.
- The wind statistics distinguish between easterly and westerly wind directions. As a result, the description of the wind statistics for this area is particularly complex.
- The wind statistics per hour are converted to wind statistics per tidal period. So, what precisely is happening here?
- Europort area and seiches: To what extent do extreme storms and seiches occur together, or not?
  Background:
  Seiches can be important here during or shortly after the closure of the storm surge barriers: the seiches are then a particular threat to the stability of the actual storm surge barriers. (The role of the seiches in the Tidal River area can be processed into the failure probability of the storm surge barriers.)
  In the case of extremely high water levels, seiches will be less important, if they occur at all, because of the damping from the flooded quay areas. But there is still the question of whether the phenomenon of seiches can occur during extreme storm conditions: perhaps it is then not possible for the required cellular structure in the weather system to be present.

Vecht and IJssel delta (Hydra-VIJ)

- To a large extent, this method corresponds to that of the Tidal Rivers. The water levels at the edge of the IJsselmeer are of course strongly related to those produced by the method used for the Lakes.

Upper rivers (Hydra-R)

- The discharge, not the wind, is the dominant stochastic parameter for the upper rivers. Despite this, the influence of the wind is still important to wave generation. The ‘representative’ wind speeds for this are not in the extreme range and so do not have to be extrapolated.
- The current approach uses a design wind speed for each wind direction that is independent of the RW model and is derived from series of measurements from a number of KNMI stations.
- One of the unanswered questions concerns the wind statistics during high water: is there a correlation?

Annex 6: Wind climate changes

The old climate scenarios do not include a prognosis for changes in wind climate. Until recently, publications on climate change stated that there was insufficient wind-related information to make any statements regarding wind climate change. As a result, most RWS applications are based on the assumption of 'no wind climate change'. Only in the case of scenarios in which it is sensible to keep certain options open, such as for the reservation of space (see the 3rd Coastal policy document), was it recommended to take a '10% increase in wind' into account.

However, a prognosis for wind climate change has been included in the most recent climate scenarios produced by the KNMI (2006). This concerns the expected percentage increase in the highest daily average of the wind speed per year. Unfortunately, this parameter is not very compatible with the wind information needs within the framework of flood protection. This will be further explained below. But first we will comment on the amount of change within the scenarios.

The amount of change (maximum of 4%) in the highest daily average of the wind speed per year may not sound alarming but this is primarily because this increase is considerably smaller than the existing uncertainty in relation to the wind in the current climate[4]. In other words: changing insights (increases in knowledge) in relation to wind in the current climate can have a considerably greater impact on the view of flood protection than the climate scenarios currently being presented.

But as we have already said, the information currently being offered regarding changes in wind climate does not provide a handle for meaningful statements on the state of flood protection in the Netherlands. This will be further explained below.

The wind information in the new climate scenarios includes the following **practical problems**:

a) The frequency of once per year is too high. This statistical value can only be relevant for water systems in which wind is not dominant, such as tidal rivers in which the discharge is dominant. For most other defence structures, information is required about much more extreme situations, which are therefore much rarer, in the order of 1/10000 per year.
b) The *daily* average of the speed is a value that has been averaged many times: the current statistics used in flood protection considerations are based on *hourly* averages. The determination of which average has appropriate dimensions will depend on the reaction speed of the water system under consideration. However, a daily average is certainly not suitable.
c) There is no information in respect of wind direction.
d) There is no information in respect of location.

The wind statistics also have the following more **fundamental problems** that also exist in respect of the current extremes climate:

e) The curvature problem.
f) There is no information in respect of storm progression in space and time (storm duration, wind rotation)

Two relatively recent publications give an impression of **uncertainty in respect of wind climate changes** and of the [uncertainty in respect of] reliability of measurements and modelling related to wind climate:

g) In an analysis of the 'storminess' of the past decades, (Smits et al, 2005) established that the measurements show a gradual decrease in storminess, while the model (re)calculations for this period show an increase. However in their conclusions, the authors attach slightly more

[4] If we should exactly understand the current wind climate, the effect of a 4% increase (with quite a lot of assumptions, including the assumption that this also applies under extreme conditions) would be appreciable. In a wind dominated system such as the IJsselmeer area, the required dike height (measured in respect of an average water level) is slightly progressive, depending on the wind speed. A 4% increase in wind speed will result in an increases in the required crest height of slightly more than 4%. In the case of a required crest height of 5 to 6 metres, the required increase amounts will still amount to a good 20 to 24 cm.

value to the measurements. However, this concerns relatively moderate storms: storms that occur on average once a year or more[5].

h) In his dissertation, (Van den Brink, 2005) demonstrated that a climate change, in this case an increase in CO_2 level, results in an increasing risk of 'super storms' in our own region. This conclusion is based fairly heavily on model calculations. This involves very rare storms that are not yet contained in the current extreme value statistics.

Conclusion: An important step forwards has been made by already focusing attention on wind in the climate scenarios. Unfortunately the resulting information regarding the (expected changes in) the wind climate does not provide us with enough of a foundation to determine the outlook for flood protection in the Netherlands. The wind climate, and the possible future changes contained within it, will for the time being remain a major factor of uncertainty in the considerations of flood protection.

Work is being performed outside the SBW project to map out and take account of wind climate change. As there are important connections with work being performed within SBW, this will be examined further below.

A few main focal points for this are:

- What is meant by a scenario that has “10% more wind”? Which wind parameters do we need in climate scenarios? This question is already more than trivial in the current method (RW model), and this is only likely to increase in the, as yet unknown, innovative method.
- In the Hydra philosophy (set of HBC instruments), a change in the wind climate can be processed in the statistics files. However, this will be difficult because the files are less than clear (in addition they are sometimes linked to water level statistics) and, because of differences in the methods, can also be different for each water system.

[5] Note that the new climate scenarios for wind are in general related to this category of storm and that evidently a *change in trend* is expected: a decrease in storminess has occurred over the past few decades and that consolidation or a slight increase is expected over the next few decades.

Annex 7: Common ground with parties abroad and/or related areas of expertise

The following is an initial draft of a list of possible aspects of common ground with parties abroad and/or related areas of expertise.

Wind energy

North Sea wind: partnership between Nuon and Shell for the development, Construction and management of the Egmond aan Zee Offshore Windpark (http://www.noordzeewind.nl). The sea-based wind park also has a high wind measurement mast.
Senternovem: an agency of the Ministry for Economic Affairs that implements government policy in the area of innovation and sustainability. (http://www.senternovem.nl). The background report 'Windkaart van Nederland op 100 m hoogte' (*wind map of the Netherlands at a height of 100m*) from 2005 uses the results of the KNMI Hydra project.
Risø National Laboratory, Department of Wind Energy and Atmospheric Physics (http://www.risoe.dk/Research/sustainable_energy/wind_energy.aspx)
WAsP Engineering. Climate atlas (http://www.waspengineering.dk).
DHI Wind-Wave Interaction for Off-shore Wind Energy Utilization (http://www.risoe.dk/Research/sustainable_energy/wind_energy/projects/WindWave.aspx)
Ecofys. (http://www.ecofys.nl/nl/expertisegebieden/duurzameenergietechnologieen/windenergie.htm)

Shipping, offshore technology, coastal hydraulic engineering

Ocean weather (http://www.oceanweather.com)
Risk engineering. Estimation of 10-4 waves using synthetic storms. Phase II-NS: Extension of Deductive Models to North Sea Storms. (http://www.riskeng.com/NS_1E-4/) (This page contains links to material generated as part of a Joint Industry Project. Access to these files is restricted to AEA Technology, its sponsors (NUG), Chevron Petroleum Technology Company, Ifremer, and consultants to the project.)
Rijkswaterstaat is a partner (NUG) and therefore has access to the project results, but does not have the right to distribute the project results.

Aviation

<yet to be determined>

Construction

<yet to be determined>

Remote sensing, satellite observations

Esa: Aeolus. Esa's satellite for wind observations. (http://www.esa.int/esaLP/ESAES62VMOC_LPadmaeolus_0.html)