F132ijsse[001-028]: Lake IJssel

Purpose

The wave conditions at the transect of measurement poles (FL47/48/49) at Lake IJssel, in the northwest of the Netherlands, can be used to study wave growth with short wind fetches and the shape of wave spectra with SWAN, see Deltares (2013) and Deltares (2014).

Situation

Lake IJssel (Figure 1) is approximately 20 by 60 km in size. Up to 1932, prior to the construction of a dam, Lake IJssel and Lake Marken were connected to the Wadden Sea, together forming the Zuiderzee. A significant part of its shores consists of dykes that were constructed between 1928 and 1976. At present, Lake IJssel is a large lake with a typical depth of about 4-5 m, and has a fairly flat, sandy bottom. The lake is therefore shallow compared to its horizontal dimensions. Wind and wave data for this lake are available from 1997 onwards.

For the investigation of wave growth with short fetches, wind, wave and waterlevel data from FL48 and FL49 are used. Also some other locations that are more remote from the shore are used in Deltares (2013), see Table 1. (This table is a copy of Table 2.1 of Deltares (2013))

Table 1. Measuring locations

***) computed from first wet grid point in SWAN bathymetry file. This column contains values only for locations for which SWAN computations have been carried out. Displacements of the instruments due to seasonal deployments and recoveries are limited.**

id	name	X [m RD]	Y [m RD]	date	(shortest) distance from shore* [m]	operational in 2013
FL02	Rotterdamsehoek	166619	529034	> Mar 2012		yes
FL02	Rotterdamsehoek	166612	529044	> Feb 2013	2356	yes
FL09	Friese kust	161832	535888	> Mar 2012	3821	yes
FL09	Friese kust	161771	535925	> Feb 2013		yes
FL25	Enkhuizen	149006	526012	slight variations through the years	776	no
FL37	Houtribdijk	155500	520000		1103	no
FL46	IJsselmeer mid	162152	524752	> Mar 2012		yes
FL46	IJsselmeer mid	162145	524741	> Feb 2013		yes
FL47	IJsselmeer mid N	144018	547259	> Mar 2012	9933	yes
FL47	IJsselmeer mid N	144020	547247	> Feb 2013		yes
FL48	Oude Zeug	136929	542952	> Mar 2012		yes
FL48	Oude Zeug	136935	542958	> Feb 2013	1660	yes
FL49	Oude Zeug Kust	136201	542585	> Mar 2012		yes
FL49	Oude Zeug Kust	136210	542585	> Feb 2013	848	yes

Case selection

In total, 28 cases are created. The first 20 (so f132ijsse[001-020]) are discussed in Deltares (2013). The remaining 8 (so f132ijsse[021-028]) are first discussed in Deltares (2014).

The case selection for the first 20 cases is discussed in Section 2.6.2 of Deltares (2013), see in particular Table 2.2 and Appendix B therein. In that study, in total 20 cases are selected. Each case contains one measurement point. Note that the first six rows in Table 2.2 in that document represent actually two cases (one for FL48 and one for FL49). Cases IJG, IJH and IJK are from Bottema (2007), and have already earlier been included in SWIVT (respectively cases f130ijsse004, f130ijsse005 and f130ijsse006). However, in Deltares (2013) they are recomputed on a different grid. This means that they can be considered as new cases, which accordingly are included in the f132ijsse-series.

The case selection for the remaining 8 cases is discussed in Section 3.1 of Deltares (2014). These cases consider either FL48 or FL49, and are labeled H, I, J and K. (Note that Deltares (2014) states that case K took place at 2 december 2013; the correct date is 5 december 2013).

These 28 SWIVT cases are gathered in Table 2. Here, the Id is the number of the SWIVT cases (f132ijsse[Id]). The observed wind speed, wind direction, water level values and wave height values in the measurement locations are included.

Recent research has indicated that the measured wave height values may be significantly overestimated due to wave run-up against the step gauges, perhaps by as much as 10% or even more.

Table 2. SWIVT cases f132ijsse.

Id	Time	Loc	U10 [m/s]	Winddir [ºN]	W.level [m+NAP]	Hm0 [m]
001	IJG: 08-01-05 13:00	FL25	17.2	245	-0.45	0.32
002	IJH: 12-02-05 15:00	FL25	17.8	287	-0.38	0.44
003	IJK: 18-01-07 12:00	FL37	22.4	230	-0.24	0.76
004	A: 31-08-12 06:10	FL09	15.5	6	-0.18	0.74
005	A: 04-10-12 16:20	FL47	8.6	276	-0.29	0.43
006	A: 04-10-12 16:20	FL48	7.1	273	-0.32	0.22
007	A: 04-10-12 16:20	FL49	6.8	276	-0.32	0.17
008	B: 25-11-12 12:00	FL48	18.1	223	-0.50	0.82
009	B: 25-11-12 12:00	FL49	18.0	225	-0.52	0.66
010	D: 31-12-12 03:00	FL48	15.9	222	-0.01	0.71
011	D: 31-12-12 03:00	FL49	15.0	223	-0.02	0.52
012	A: 24-03-13 06:20	FL02	15.0	91	-0.57	0.50
013	E: 18-04-13 12:20	FL48	17.2	235	-0.37	0.82
014	E: 18-04-13 12:20	FL49	16.7	233	-0.38	0.62
015	F: 10-05-13 10:40	FL47	14.0	239	-0.21	1.00
016	F: 10-05-13 10:40	FL48	14.4	245	-0.30	0.58
017	F: 10-05-13 10:40	FL49	13.2	243	-0.29	0.40
018	B: 16-05-13 19:50	FL09	14.2	12	-0.18	0.46
019	G: 13-06-13 12:20	FL48	15.7	232	-0.29	0.65
020	G: 13-06-13 12:20	FL49	14.9	231	-0.29	0.49
021	H: 27-10-13 12:20	FL48	17.8	245	-0.46	0.73
022	H: 27-10-13 12:20	FL49	16.4	244	-0.46	0.50
023	I: 28-10-13 11:20	FL48	25.1	239	-0.68	1.11
024	I: 28-10-13 11:20	FL49	23.7	231	-0.74	0.88
025	J: 28-10-13 12:00	FL48	23.7	244	-0.68	1.01
026	J: 28-10-13 12:00	FL49	22.4	244	-0.73	0.85
027	K: 05-12-13 13:40	FL48	18.7	243	-0.56	0.85
028	K: 05-12-13 13:40	FL49	17.1	245	-0.58	0.57

Model setup

Section 2.6.3 of Deltares (2013) and Section 3.2 of Deltares (2014) give information on the model setup. The most important elements are repeated here. The setup of the reference runs is more or less similar to the SWAN simulations for WTI. Both concern stationary runs with SWAN version 40.72ABCDE. For each location a dedicated computational rectangular grid has been set up, see Figure 1 (a copy of Figure A.2.2 of Deltares (2013).

Geographical and spectral discretisation

The geographical resolution is 20 m x 20 m. Only the computational grid for FL25 and FL47 are an exception on this. For FL25 (cases 001 and 002), the resolution is 10 m x 10 m. For FL47 (cases 005, 015), the grid covers a larger area and to prevent memory errors, the resolution is 20 m x 40 m (coast parallel).

The frequency domain is 0.08 - 4.0 Hz, by SWAN divided into 41 bins. The directional resolution is 10°, covering the full circle. Although the spectral domain stretches to 4 Hz, the output quantities are computed on 0.08 – 1.5 Hz in order to compare with the observations which are computed on 0.03 to 1.5 Hz. From 0.03 to 0.08 Hz we assume the variance density to be negligible.

Bathymetry

For the older cases from Bottema (2007) (cases 001, 002, 003) and for case 012, the bottom file from the SWIVT data base is used ('f130ijsse00X.bot'), which is identical to the bottom file used by Bottema ('ijsm99.bot'). It has a resolution of 40 m x 40 m.
For cases 004 to 020 (except case 012) the bathymetry is taken directly from the bottom file as used in the WTI 2011 computations for Lake IJssel ('G1U14S022S01.bot'). The resolution of this file is also 40 m x 40 m.
For cases 021 to 028 (Deltares (2014)) the bathymetry is taken directly from a slightly different file ('G1U14D022S01.bot'). The resolution of this file is also 40 m x 40 m.

Wind and water level input

The wind velocity and wind direction are taken directly from the 10 min averaged wind observations at the location of the considered wave measurements and applied uniformly over the specific domain. (In Deltares (2014), the values of FL48 were always taken, also for the FL49 computations)

This also holds for the water levels for the first 20 cases, which are supposed to be uniform over the computational grid. For the last 8 cases, the water level is provided as a spatial field linearly interpolated through the observed water levels at locations FL48 and FL49.

The wave boundary condition is set at zero. Currents are assumed to be negligible.

Default settings

The computations in Deltares (2013,2014) are performed with SWAN version 40.72ABCDE.

These physical settings are based on the settings as used for WTI2011. The only difference is the value for the friction coefficient which was 0.067 m^2s^{-3} in the WTI runs for Lake IJssel and the *Benedenrivieren*, whereas here in the benchmark tests, we used 0.038 m^2s^{-3} which is advised in the WTI settings (Deltares (2010)).

For the deep water physics the saturation based whitecapping according to Van der Westhuysen (2007) (with default $C_{ds2}=5*10^{-5}$ (being the proportionality coefficient) and $B_R=1.75*10^{-3}$ (the threshold spectral saturation level)) is used. Quadruplet nonlinear interaction is modelled using the Discrete Interaction Approximation (DIA) of Hasselmann et al. (1985). The shallow water source terms include triad nonlinear interactions according to Eldeberky (1996). For depth-induced breaking, the formulation of Van der Westhuysen (2010) is applied. The exact SWAN input for the physics – in Deltares (2013) called the reference settings – is given below:

```
$ --- Fysische parameter settings
      GEN3  WESTH
      WCAP  WESTH cds2=5.0e-05 br=0.00175 p0=4.0 powst=0.0 powk=0.0 &
                  nldisp=0.0 cds3=0.8 powfsh=1.0
      QUAD  iquad=2 lambda=0.25 cnl4=3.0e+07
      LIMITER ursell=10.0 qb=1.0
      FRIC  JONSWAP cfjon=0.038
      BREA  WESTH alpha=0.96 pown=2.50 bref=-1.3963 shfac=500.0
      TRIAD trfac=0.1 cutfr=2.5
```

However, these settings cannot be used with later SWAN versions (e.g. 4091 and later). Therefore, the following SWAN settings, based on the defaults, have been inserted instead. Note that they may not be the optimal SWAN settings for these cases.

```
GEN3  KOM
WCAP KOM cds2=2.36E-005 stpm=0.00302 powst=2 delta=0 powk=0
QUAD  iquad=2 lambda=0.25 cnl4=3.0e+07
LIMITER ursell=10.0 qb=1.0
FRIC  JONSWAP cfjon=0.038
BREA  CON alpha=1.0 gamma=0.73
TRIAD trfac=0.1 cutfr=2.5
```

The numerical settings include the curvature stopping criterion of 0.001, on at least 99.5% of the wet grid points, with a maximum number of iterations of 100. A small degree of under-relaxation was applied to improve convergence-behaviour (alfa=0.001):

```
NUM STOPC dabs=0.00  drel=0.01  curvat=0.001  npnts=99.5  STAT mxitst=100
alfa=0.001
```

In the WTI runs for the *Benedenrivieren*, the required percentage of grid points to reach convergence was slightly less (99% instead of 99.5%), and also the maximum number of iterations (80 instead of 100).

References

Bottema, M (2007). Measured wind-wave climatology Lake IJssel (NL), RWS/RIZA report 2007.020. July 2007.

Deltares (2013). SWAN uncertainties for short fetches. Deltares Report 1207807-001-HYE-0008, Dec 2013.

Deltares (2014). SWAN uncertainties based on additional Lake Ijssel cases. Deltares report 1209433-007-HYE-0009, Dec 2014.

Acknowledgements

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Figure

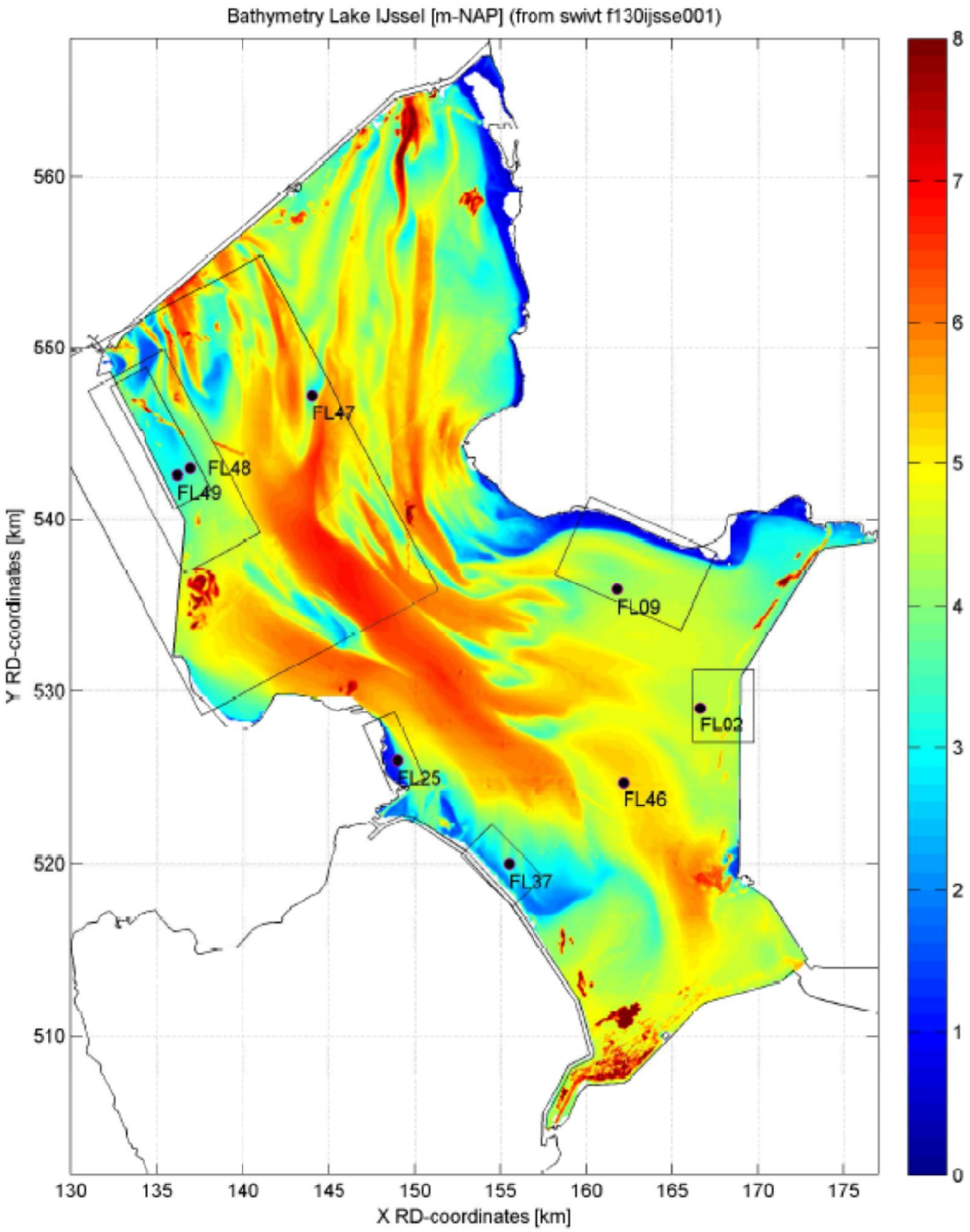

Figure 1. Lake IJssel ,measurement locations and dedicated SWAN grid domains.