Mike11 系统在长江’98 年洪水中的应用

李明新 李世强 邹冰玉

长江水利委员会水文气象预报处

提要：丹麦水力研究所开发的 Mike 11 系统 1995 年在长江中游进行了初步建模试验，1998 年模型正式投入作业预报试运行，在螺山以下河段的水位预报中，1-3 天的预报精度接近发布预报精度， Mike 11 的实用性在洪水作业预报中得到了检验。

一、合作概况

1998 年初中国与丹麦的合作项目“长江中下游暴雨洪水预报”（二期）进入模型参数的率定优化阶段，5 月底中方培训人员完成了模型参数的初步率定工作，并于 6 月 12 日开始将软件联入我处计算机网络，正式开展作业预报试运行，正值长江中下游发生了继 1954 年以来又一次全流域大洪水，本系统也得到一次难逢的检验机会。根据 6 月份运行中发现的问题，丹方专家 7 月初来汉进行了模型参数的进一步优化修改工作，于 7 月 3 日开始每天与现行的模型平行运行，主要用于制作螺山以下河段的水位预报。作业预报中，预报员根据各模型的计算结果及模型的性能特点，结合预报员的经验，综合会商一个预报值供对外发布使用。在 98 年汛期中，Mike 11 预报值对提高洪水预报精度作出了一定的贡献。

二、 预报成果比较

从 6 月 17 日开始，至 9 月 16 日主汛期基本结束，Mike 11 系统每天使用 8 时水文资料进行计算，得到宜昌、枝城、沙市、石首、监利、城陵矶、螺山、汉口、黄石、武穴、九江、湖口等站的水位预报计算成果。

在 1998 年长江汛期，我处使用各种模型进行水位、流量预报工作，因此在分析 Mike11 系统预报成果时，也和同步运行的其他各预报方案和预报模型的结果进行比较。

宜昌、螺山、汉口是长江中下游防汛的关键站，可代表模型的应用情况。首先对此三站 1-3 天的预报成果进行比较分析。

图一绘出了宜昌站实测水位、Mike 11 预报值、预报发布值的对照情况。预报发布值采用的是现行预报方案。从图示可知，24 小时预报 Mike 11 的预报水位接近预报发布值，而 48 小时与 72 小时 Mike 11 的预报水位误差略大一些，但预报线的趋势正确。

图二显示了螺山站实测水位、Mike 11 预报值、大湖演算预报值、预报发布值的对照情况。预报发布值则参考了大湖演算和 CRFPDP 实时模型预报值，加上预报员经验确定发布水位预报值。从图示可知，24 小时预报 Mike 11 和大湖演算的预报值与发布值接近，对于

48 小时与 72 小时预报，由于发布值不包含预见期降雨，故在洪水上涨期有大量预见期降雨时，预报偏低，而 Mike 11 则通过水量差的现实校正处理部分弥补了这一误差，显得在 6 月份涨水段预报效果更好一些。

图三显示了汉口站实测水位、Mike 11 预报值、预报发布值的对照情况。预报发布值根据的是现行预报方案，即上下游水位相关，预报员经验判断相关图的可信度，参考 CRFPDP 模型预报值综合出水位预报发布值。从图示可知，24 小时预报 Mike 11 的预报水位接近预报发布值，对于 48 小时与 72 小时预报，也有与螺山站类似情况。

对于螺山、汉口站 4-5 天的预报结果进行比较分析，Mike 11 在 6 月份涨水段的预报水位与我处原现行模型值接近，但在 7 月下旬至 8 月份，效果比现行模型差。

三、 预报误差分析

Mike 11 系统采用的是水动力学模型，在洪水预报生产中使用是一种尝试。在中丹合作二期工作中，系统以长江上游干流寸滩站、乌江的武隆站、清江的长阳站、沮漳河的河溶站、洞庭湖四水出口控制站、汉江的丹江口水库和鄱阳湖的五河控制站等流量作为上边界，大通站水位作为下边界，预报边界的准确性同样对系统的预报精度有影响。由于边界众多，在运行中预报边界条件的时段长取为 24 小时，难以反映监利以上河段的水情变化，这是监利以上河段预报结果不理想的重要原因。

四、HIRLAM 与 Mike 11 的耦合

HIRLAM 与 Mike 11 的耦合，可以在水文预报上直接使用降水预取成果，具有重要的意义。根据系统中的子流域划分，DMI（丹麦气象研究所）在汛期每天提供以 6 小时为时段长未来的 48 小时分区定量降水预报。在汛期结束后，利用汛期相同的预报条件，加入 HIRLAM 的降雨资料重新进行计算，从关键站的预报结果来看，在预见期降雨较大时，加入预报降雨可以提高预报精度。

五、结语

通过 1998 年长江大洪水试运行，在长江上建立的 Mike 11 预报系统，在 1-3 天预见期内可得到与现行预报模型相近的结果，特别在 6 月份洪水上涨期，其水量实时校正的处理部分弥补了预见期降雨形成的误差，是本模型的一种优点，在作业预报中，有相当的参考价值。建议从 1999 年汛期开始，将本系统作为长江中下游的实用洪水预报模型正式投入生产。

Review of Trial Operation of MIKE 11 System in 1998 Changjiang Flood

Li Mingxin Zou Bingyu Li Shijiang
Division of Hydrological and Meteorological Forecast, Bureau of Hydrology, Changjiang Water Resources Commission(CWRC)

ABSTRACT

The MIKE11 system developed by Danish Hydraulic Institute (DHI) was initially experimented to model the middle reaches of the Changjiang in 1995, and then put into trial operational forecast in 1998. In the water stage forecast on the reaches downstream of Luoshan, its 1-3 day forecasting accuracy approximates that of the forecast issued, verifying its practicability.

1. Introduction

The Sino-Danish cooperative project Heavy Rains and Flood Forecasting in the Middle Changjiang River Valley(Phase II) stepped into the stage of refining parameter calibration of the model in early 1998. The Chinese trainees in Denmark completed the parameter calibration of the model in the end of May 1998, and loaded the software into the computer network of Division of Hydrological and Meteorological Forecast on June 12 for trial operational forecasting. The trial operation of the model coincided with the whole Changjiang Basin flood which was another event as occurred in 1954, a good chance for the system verification. In the light of the problems arising in system operation in June, Danish specialist came to Wuhan in early July to further refine the model parameters. Starting from July 3, MIKE11 run in parallel with the current operational forecasting models every day, mainly to forecast the water stages downstream of Luoshan. The present Changjiang flood forecasting practice does not take into account the precipitation in the lead time. In operational forecast, the forecasting staffs elicit a forecast value for issuing based on the computed results and characteristics of different models in combination with their own experience. In 1998 flood season, the forecast value given by MIKE11 contributed to some extent to increasing the flood forecasting accuracy.

2. Comparison of forecasting results

From June 17 to September 16 (the end of main flood season), MIKE 11 system was run every day fed with the daily hydrological data received at 8:00 to work out the water stage forecast for the stations at Yichang, Zhicheng, Shishou, Jianli, Chenglingji, Luoshan, Hankou, Huangshi, Wuxue, Jiujiang, Hukou and etc..

In 1998 Changjiang flood season, other models worked in parallel with MIKE 11 for comparison analysis and cross-verification.

Yichang, Luoshan and Hankou station are 3 key ones for flood control of middle and lower reaches, so the forecast values in the lead-time of 1-3 days at these 3 stations are first used to do comparison.

Fig.1 shows the comparison between the observed water stage, MIKE 11 forecast and forecast

issued at Yichang station. The issued forecast is the product of current operational forecast scheme, which is to forecast the flow process at Yichang using Muskingum method routing meanwhile taking into consideration of local inflow in an interactive way, then to figure out the water stage from the water stage correlation and real-time water stage-flow relationship curve. As is shown on the figure, the 24-hour water stage forecast of MIKE 11 approximates the forecast issued. Whereas its 48-hour and 72-hour forecast deviate from the forecast issued a little bit, but the lines are in the same tendency.

Fig.2 shows the comparison between the observed water stage, MIKE 11 forecast, Lake Flood routing method forecast and the forecast issued at Luoshan station. The forecast issued is derived comprehensively from the lake flood routing method forecast, CRFPDP model forecast(real time) together with the experience of the forecaster. As is read from the figure, MIKE 11 is near to the lake flood routing method in 24-hour forecast. As for 48-hour and 72-hour forecast, MIKE 11 seems better than the forecast issued in the river-swelling period of June, for the reason that the forecast issued does not consider the rainfall in lead time while MIKE 11 partly compensates this error by means of water amount correction.

Fig.3 is the comparison between the measured stage, MIKE 11 forecast and forecast issued at Hankou station. The water stage forecast issued is a comprehensive one derived from the current forecast scheme, i.e. combination of correlogram of upstream and downstream water stages, experience of forecaster in judging the credibility of the correlogram and CRFPDP model forecast. The 24-hour water stage forecast given by MIKE 11 is approximate to the forecast issued, and its 48-hour and 72-hour forecast is similar to the case of Luoshan station.

Comparison analysis on the 4-5 day forecast results for Luoshan and Hankou station shows that the water stage forecast done by MIKE 11 approximates that of our current operational model in the river-swelling period of June, but in late July and August, MIKE 11 behaves inferior to our current model.

3. Forecasting error analysis

MIKE 11 adopts the hydro-dynamic model as an attempt in flood forecasting. In the second phase of Sino-Danish cooperative project, the upper boundary conditions are the flows at Cuntan station on the Changjiang mainstem, Wulong station on Wujiang river, Changyang sation on Qingjiang river, Herong station on Juzhang river, stations at the 4 outlets of Dongting Lake, Danjiangkou reservor station on Han river and Wuhe controlling station of Poyang Lake. The lower boundary condition is the water stage at Datong station. The accuracy of boundaries has impact on the accuracy of forecasting. The multitude of boundaries and the fact that the assumed 24-hour time interval in boundary condition can not reflect the water regime changes on the reaches upstream of Jianli explain the unsatisfactory forecasting results for the reaches upstream of Jianli.

4. Coupling of HIRLAM and MIKE 11

The coupling of HIRLAM and MIKE 11, enabling the flood forecasting to make direct use of precipitation forecast is of great significance. DMI, in term of the watershed elements of the system, provided 48-hour quantitative precipitation forecast every day in the flood season of this year at the interval of six hours.

Owing to different reasons, the operation of coupling of HIRLAM with MIKE 11 in 1998 Changjiang flood was not normally conducted. After the flood season, the re-computations using

the same forecasting conditions as in the flood season with introduction of the precipitation data of HIRLAM show an increase of forecasting accuracy in case of heavy rainfall in lead-time, as far as the forecasting results for some key stations are concerned.

5. Summary

The trial operation of the Changjiang MIKE 11 forecasting system during 1998 Changjiang flood demonstrates that its forecasting result is approximate with that of the current models within the lead-time1-3 days. Especially during June when the river was swelling, the real-time water amount correction module of MIKE 11 remedies partly the error caused by the rainfall during lead time. This advantage of MIKE 11 makes it reference-worthy in operational forecast. It is recommended that, from the flood season of 1999 on, MIKE 11 should be put into operational use in the middle and lower reaches of the Changjiang as a practical flood forecasting model.