

Early History of the Operational Numerical Weather Prediction in Japan

By
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1. Initial activities in NWP in Japan

Stimulated by the remarkable worldwide development of modern meteorological studies, particularly those of the general circulation of the atmosphere, of the dynamic meteorology and of the numerical weather prediction (NWP), various activities started to introduce and further develop results of these studies in Japan.

Around the end of 1953, a Numerical Weather Prediction Group (usually, called NP Group in Japan) was formed in Tokyo under the leadership of S. Syono, taking over the General Circulation Group which was formed earlier in June 1953. The Group members consisted of the staffs of the University of Tokyo, researchers at the Meteorological Research Institute (MRI) of the Japan Meteorological Agency (JMA) and some staff members at JMA. Later, from the end of 1954, the Group members were expanded to include personnel at the local meteorological offices at Sendai, Niigata and Osaka. In May 1954, the Group was granted by the Asahi Shinbun, one of the biggest newspapers companies in Japan, a rather large sum of money for its research activities. The grant really contributed greatly to encourage and enhance research efforts of the Group, considering the shortage of research fund at that time.

Research activities of the NP Group then covered, for example, NWP of typhoon track by Y. Sasaki and K. Miyakoda, an original study of Japanese product, a three-layer model (by A. Kasahara), a two-parameter model (by K. Ooyama), an experimental extended forecast (by Y. Masuda and T. Murakami) and a formulation of computational method using the Fourier series (by K. Gambo, S. Kubota and Y. Kurihara). Most of these studies were carried out by graphical methods, but others were computed by a relay computer of the Fujitsu Co. (FACOM 100), a relay computer at the Electronic Research Laboratory, a governmental research organization (MARK II) and also the small electronic computer IBM 650.

Members of the NP Group at the beginning stage were as follows:

S. Syono, Y. Ogura, K. Gambo*, A. Kasahara, Y. Sasaki, K. Miyakoda, M. Aihara, S. Manabe, Y. Kawata, M. Yanai, and T. Matsuno, of the University of Tokyo, S. Kubota*, S. Matsumoto, H. Ito*, T. Murakami, M. Magata, M. Takeuchi, Y. Masuda*, and A. Arakawa* of MRI, K. Mohri*, N. Arizumi, H. Isobe*, Y. Nabeshima*, E. Terauchi*, S. Fujiwara*, K. Ooyama*, N. Saito*, Y. Sekiguchi*, Y. Kurihara, Ta. Nitta*, K. Kusano, S. Ito, and T. Nagao of JMA, and T. Yokozeki of the Japan Air Lines (JAL).

Those with the asterisk were associated directly with the operational NWP.

2. Introduction of IBM 704 in JMA and start of the operational NWP in Japan

After various scientific, technical, operational and political discussions and arguments, JMA finally acquired in January 1959 what was then a "super" computer, IBM 704 (with a core Memory of 8 K words (KW)), one word consisted of 36bits; Fig.1)

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by the decision of K. Wadati, the Director-General of JMA. An organization to deal with the NWP operation called then the Electronic Computation Center (ECC) (now the Numerical Prediction Division (NPD)) was established in 1958 at the Forecast Department of JMA. The first director of the Center was H. Ito (a different person than the one listed in the Section 1) and the activities to prepare the operational NWP started in April 1959.



Fig.1. Electric Computer IBM704 first introduced in JMA. By courtesy of JMA.

3. Preparation of the NWP operations at the ECC, JMA

The NWP operations were developed by the following three task teams:

- 1) General forecast team,
- 2) Typhoon team,
- 3) Analysis team.

The original plans to prepare the operational NWP were as follows :

Team 1): A two-layer and a five-layer quasi-geostrophic models,

Team 2): A typhoon track prediction model. The test of the model was performed at the Vanguard Center by courtesy of the US Weather Bureau,

Team 3): The automatic data processing (ADP) and the objective analysis (OA). Due to the lack of experience, there were no substantial programs, before the introduction of ADP and OA programs coded by the Joint Numerical Weather Prediction Unit (JNWPU) (later National Meteorological Center (NMC)) of the US Weather Bureau.

Because of the shortage of preparation time before the start of the NWP operation at the ECC, JMA had to use the above-mentioned imported ADP and OA programs from the JNWPU to prepare the initial data for the NWP model. The first operational NWP model of JMA was a Northern Hemisphere balance barotropic (BB)

model at the 500 hPa (Fig.2). The prediction was carried out up to 48hours in 1959. In the summer season, the typhoon track prediction was additionally made by using results of the BB model mentioned above.

Within one year of the start of the routine NWP, a four-layer quasi-geostrophic (QG) model for the Far East area, and ADP and OA programs for the model were completed. Accordingly, we may say that in April 1960, preparations for the original NWP operation at the ECC, JMA had been finished and on 20 June 1960, the first real time facsimile (Fax) broadcast of the NWP prognostic charts became daily routine, as the third full NWP operation in the world following the Swedish Meteorological and Hydrological Institute (SMHI) (September 1954) and the JNWPU in USA (May 1955).

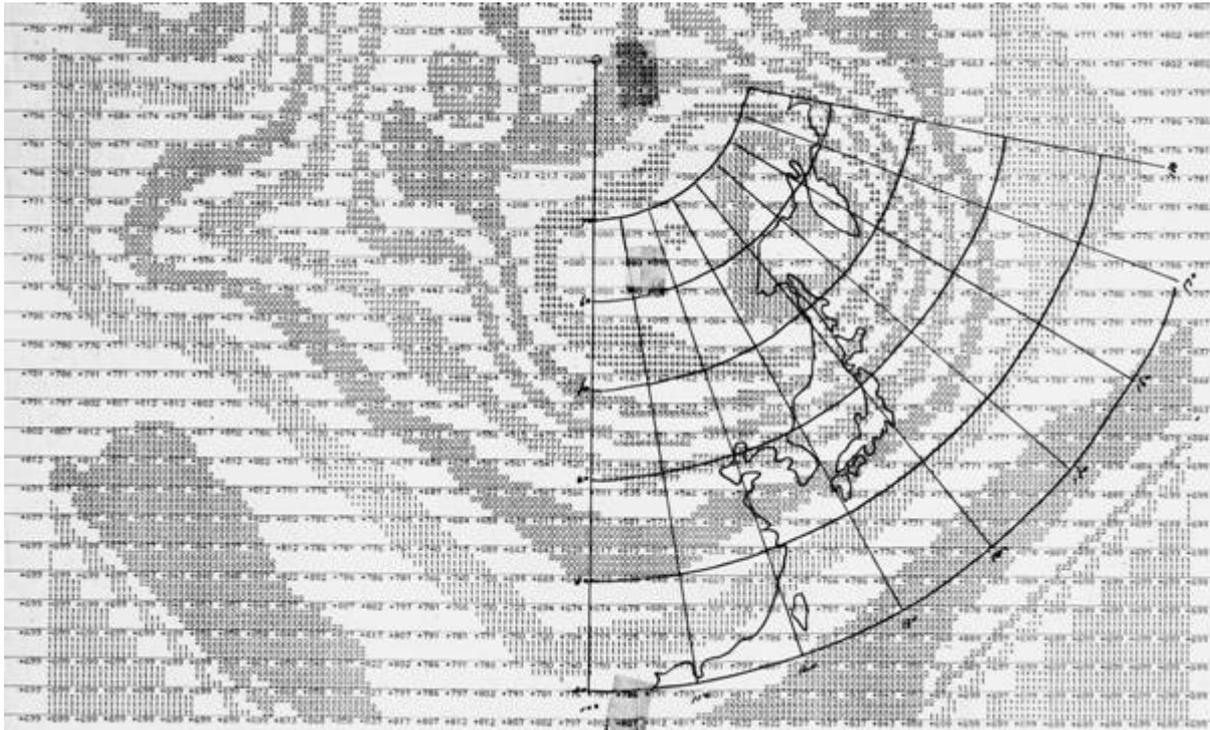
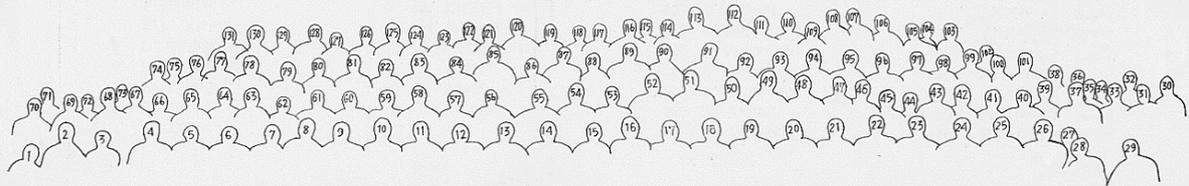
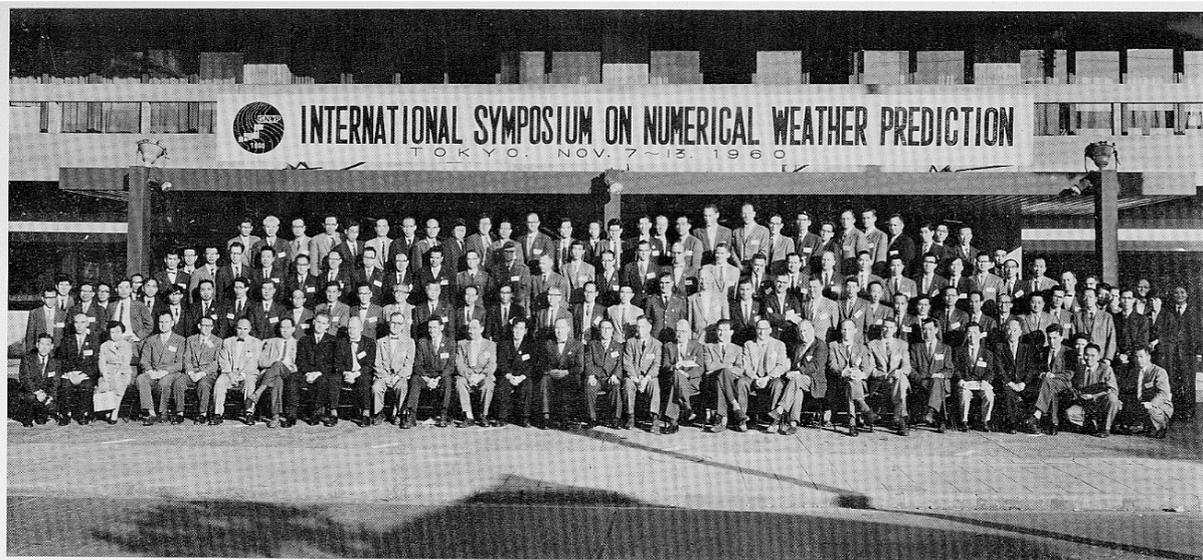


Fig. 2. Analysis of 500 hPa geopotential height at 12 UTC, 28 February 1960 with IBM704 for the initial condition of JMA Northern Hemisphere balance barotropic model. By courtesy of JMA.

4. The First International NWP Symposium in Tokyo

From 7th to 13th November 1960, the First International NWP Symposium was held in Tokyo. The impact of the outcome from the Symposium, given not only to the NWP community in Japan but also to the world meteorological community, was bigger than that could be imagined at the beginning. The Symposium was planned under the leadership of S. Syono and supported by those concerned with universities, JMA and research community. In particular, the contribution of M. Yoshitake, then one of the executives of JMA and a good friend of Syono, should be remembered. The Symposium also implicitly celebrated the introduction of IBM 704 and the start of the NWP operation at JMA. The meeting was successful in that participants covered a wide range of nationalities and specialties in the modern meteorology such as synoptic and dynamic meteorology as well as NWP (Fig. 3). Also, participation of world prominent researchers and experts provided young Japanese participants excellent opportunities to be acquainted with top meteorologists of the day and their

works.



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|--------------------|---------------------|---------------------|--------------------|
| 1. T. Takeda | 34. J. Spar | 67. K. Takeuchi | 100. K. Tomatsu |
| 2. K. Suda | 35. T. Kamiko | 68. M. Yanai | 101. M. Utsugi |
| 3. Y. Yatsuka | 36. R. Vasec | 69. T. Isobe | 102. M. Aihara |
| 4. B. Gosset | 37. T. Senshu | 70. Y. Isono | 103. K. Takeda |
| 5. H. φkland | 38. H. A. Bedient | 71. E. Machida | 104. N. Mori |
| 6. E. L. Fisher | 39. M. Okamoto | 72. K. Doi | 105. A. Katayama |
| 7. J. Namias | 40. Y. Kikuchi | 73. T. Suzuki | 106. Y. Mintz |
| 8. R. Fjφrtoft | 41. F. Kusakabe | 74. K. Tsuchiya | 107. W. L. Gates |
| 9. N. Phillips | 42. Y. Sugimoto | 75. T. Fujita | 108. M. G. Wurtele |
| 10. G. W. Platzman | 43. S. Tanaka | 76. Y. Onozawa | 109. E. Teruchi |
| 11. J. G. Charney | 44. Y. Ogawa | 77. K. Watanabe | 110. S. Matsumoto |
| 12. F. G. Shuman | 45. K. Mashiko | 78. S. Sugiura | 111. M. Magata |
| 13. K. Wadati | 46. S. Fujiwara | 79. T. Kume | 112. T. Hesse |
| 14. D. A. Davies | 47. Y. Ogura | 80. S. Kato | 113. O. Haug |
| 15. S. Syōno | 48. D. E. Martin | 81. Y. Kodaira | 114. A. Arakawa |
| 16. A. Eliassen | 49. M. M. Holl | 82. K. Koenuma | 115. K. Mohri |
| 17. R. D. Fletcher | 50. A. Thomasell | 83. B. Rodrigues | 116. H. Ito |
| 18. B. Bolin | 51. R. D. Johnston | 84. G. Hebel | 117. T. Nitta |
| 19. J. Smagorinsky | 52. J. I. Goetshius | 85. W. C. Woodworth | 118. T. Tachi |
| 20. G. Hollmann | 53. A. Kasahara | 86. D. J. Bouman | 119. Y. Nabeshima |
| 21. B. R. Dōs | 54. S. Kubota | 87. T. Asai | 120. H. Reiser |
| 22. W. D. Mount | 55. K. Terada | 88. H. Hatakeyama | 121. Y. Masuda |
| 23. H. L. Kuo | 56. K. Gambo | 89. G. 'Arnason | 122. M. Yoshitake |
| 24. G. Taniguchi | 57. S. Sakuraba | 90. F. Wippermann | 123. K. Miyakoda |
| 25. J. Sato | 58. H. Futi | 91. R. L. Pfeffer | 124. J. Orihata |
| 26. J. V. Isacker | 59. G. Horiuchi | 92. S. Penn | 125. Y. Yamanaka |
| 27. Y. Sekiguchi | 60. H. Arakawa | 93. L. Berkofsky | 126. S. Nishimoto |
| 28. M. A. Estoque | 61. G. Morikawa | 94. E. N. Lorenz | 127. T. Kitaoka |
| 29. J. Nakayama | 62. E. Inoue | 95. Y. Kurihara | 128. M. Oota |
| 30. F. Ozaki | 63. R. Sawada | 96. H. Itoo | 129. K. Agematsu |
| 31. S. Matsuda | 64. N. Saito | 97. R. Yamamoto | 130. K. Fujita |
| 32. R. T. Webber | 65. K. Tonomura | 98. Y. Mitsuta | 131. M. Takeuchi |
| 33. Y. Arai | 66. T. Matsuno | 99. N. Nakamura | |

Fig. 3. Participants of the International Symposium on Numerical Weather Prediction in Tokyo. By the courtesy of the Meteorological Society of Japan (MSJ).

The many results that the Symposium yielded were compiled in the Proceedings of the meeting and was published in 1962 (Fig. 4) by the Meteorological Society of Japan (MSJ). Papers contained in the Proceedings had to a great extent affected domestically as well as internationally the development of NWP both in the research fields and operational areas. In fact, one could trace the development of operational NWP in Japan during about a decade after the Symposium had been greatly influenced by the outcome of that meeting, for example, the introduction of the non-adiabatic effects and changes of the operational NWP models from the quasi-geostrophic version to the primitive equation (PE) model through the balance model.

The NP Group played a remarkable role to compile and edit the Proceedings of the Symposium, but the Group practically ended its well-organized activities as a group at a time and shifted mostly to keeping a mental sense of solidarity among group members having intermittent meetings and discussions dealing with problems associated with NWP.

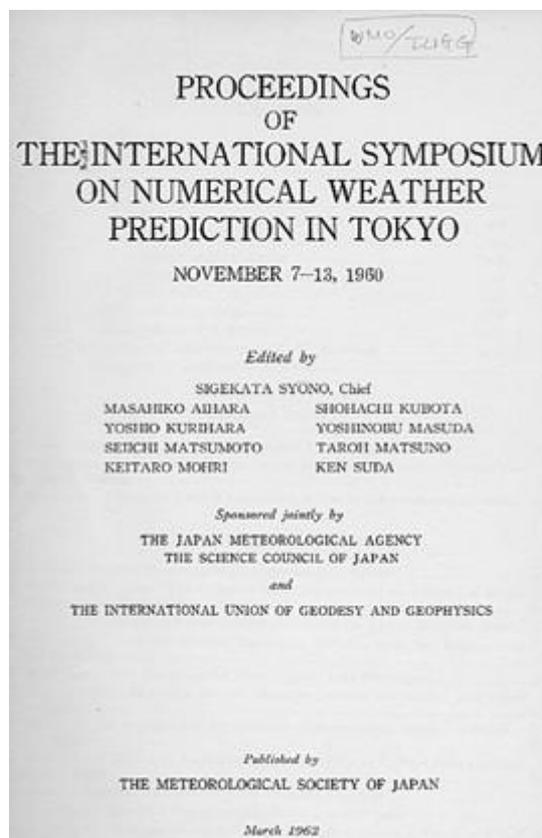


Fig. 4. Cover sheet of the Proceeding of the International Symposium on Numerical Weather Prediction in Tokyo. By the courtesy of MSJ.

5. Changes of the main computer from IBM 704 to HITAC 5020F/5020 system

In January 1965, JMA was informally told by the government that the budget was approved to upgrade the computer system from IBM 704 to the Japanese high-speed electronic computer HITAC 5020F/5020 (131KW/32KW+256KW(magnetic drum), one word consisted of 32bits), produced by one of the biggest manufacturers of electrical machinery, Hitachi Co., Ltd.

With this progress of the computational capability it could be said that the operational NWP at JMA advanced from an infant stage to a youth stage. However, as one can easily imagine, the change of whole computer system for the operational NWP, particularly between completely different types of the computer system, was not an easy task to manage. In other words, the whole system of the operational NWP which consisted of the software system associated with the NWP models and the hardware systems including the infrastructure, had to be completely shifted from the old one to the new one without any mistake.

In the case of a complicated system such as the NWP operation, in particular as was the case of HITAC 5020F/5020 which was the real first product of the computer system by the company, we needed a lot of man-power and attentiveness to accomplish this hard work. Finally, on 1st February 1967, the new computer system was put in operation.

6. The light and shadow at the growing stage

In accordance with the growth of the NWP operation in late 1960s, there were rather many intense discussions and conflicts within those associated with the NWP operation on the following points:

- 1) whether more emphasis should be put on the research and development efforts or on the expansion of the operational framework of NWP under a limited computer resources,
- 2) how to convince experienced forecasters of using NWP prognostic products much more in the operational daily weather forecasts.

As is shown in Fig. 5, gradual improvement of NWP models from the filtered versions toward the unfiltered PE versions were realized in accordance with the upgrade of computer systems for the NWP operation in Japan. At the same time, the improvement of the quality of NWP prognostic products, particularly realistic prediction of weather systems over 48hours or so with the evolution of rainfall patterns, step by step made experienced forecasters understand the merits, real values and advantages of the NWP products and become aware of the promising future of the NWP operation.

7. The Second International NWP Symposium in Tokyo

After about eight years of the First Symposium, the Second International NWP Symposium was held in Tokyo from 26th November to 4th December 1968 sponsored by the World Meteorological Organization (WMO) and hosted by JMA. Reflecting the substantial introduction of the NWP products into the operational weather forecasts in many forecasting centers in the world, the atmosphere of the second meeting was rather cool and businesslike in comparison with passionate and ardent one in the first meeting. Furthermore, themes taken up by the Symposium were more or less detailed and complicated ones rather than fundamental problems in the former conference.

8. Epilogue

We will stop this article at the point before entering to the substantial jump of the NWP operation at JMA including finer mesh PE models and adoption of the spectral method for global, regional and mesoscale models as well as typhoon model in accordance with the introduction of higher speed computers and the super computers in the following years up to now (Fig. 5).

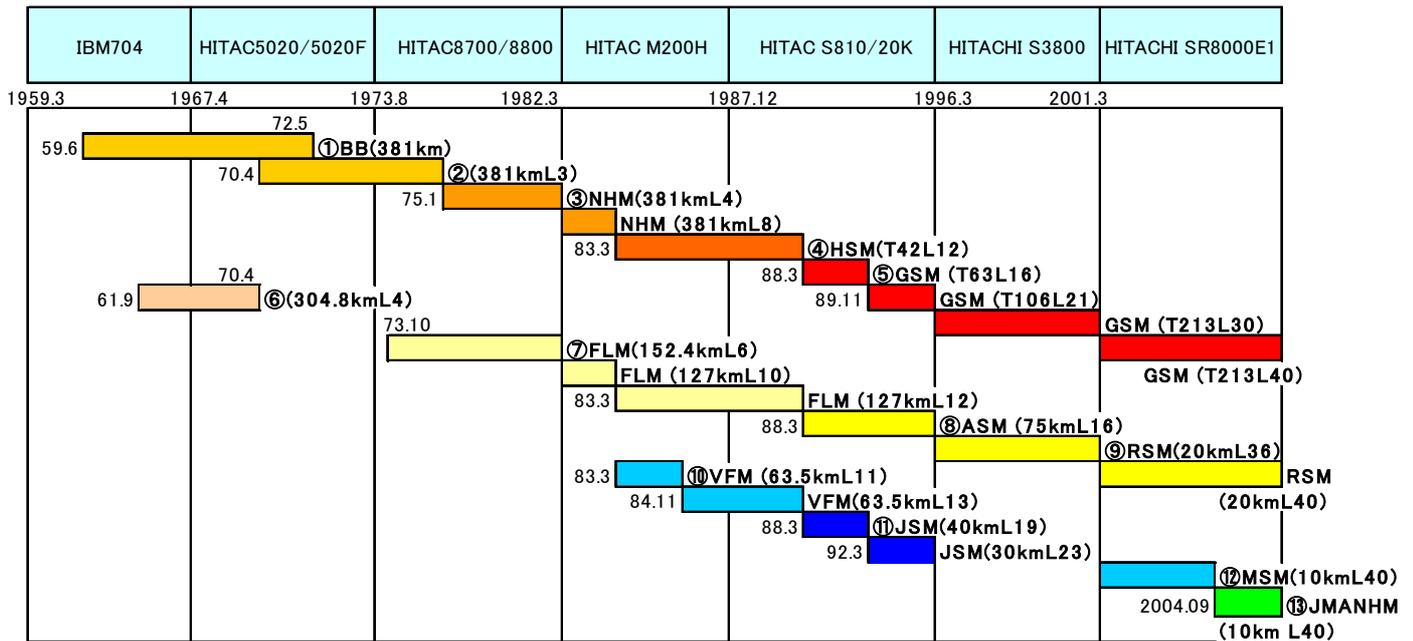


Fig. 5. Changes of operational NWP models at JMA. A number in a circle denotes an operational model shown below that was run during a period shown on the left-hand rectangle. L in a parenthesis means the number of vertical levels of the model. 1. Northern Hemisphere balance barotropic model (BB), 2. Northern Hemisphere balance baroclinic model, 3. Northern Hemisphere primitive equation model (NHM), 4. Northern Hemisphere spectral model (HSM), 5. Global spectral model (GSM), 6. Asian area quasi-geostrophic baroclinic model, 7. Asian area fine mesh limited area model (FLM), 8. Asian area spectral model (ASM), 9. Regional spectral model (RSM), 10. Very fine mesh model (VFM), 11. Japan area spectral model (JSM), 12. Mesoscale model (MSM), 13. Nonhydrostatic model (JMANHM; planned).

Acknowledgments

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