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"Third ICTP/WMO International Workshop on Tropical Limited Area Modelling "
21 October - 1 November 1996

"Typhoon/Hurricane Studies in Russia"

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Please note: These are preliminary notes intended for internal distribution only.

International Centre for Theoretical Physics

Third ICTP/WMO International Workshop on Tropical Limited Area Modelling

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"Typhoon/Hurricane Studies in Russia"

Lecture Notes

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TYPHOON / HURRICANE STUDIES IN RUSSIA

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Lecture notes

(1.) Interest in typhoon / hurricane studies in Russia

a. Theoretical aspects (the most pronounced phenomenae in tropical atmosphere), role for NWP and GCM models.

b. Western North Pacific typhoons strike the most eastern areas of Russia, including Sakhalin island and Kamchatka peninsula.

c. Transformed hurricanes coming from western and central Atlantic may influence (after passing over West Europa) the European regions of Russia, becoming extratropical cyclones.

d. Role of typhoons / hurricanes for Russian merchant and fishing fleet over the World Ocean as well as aviation.

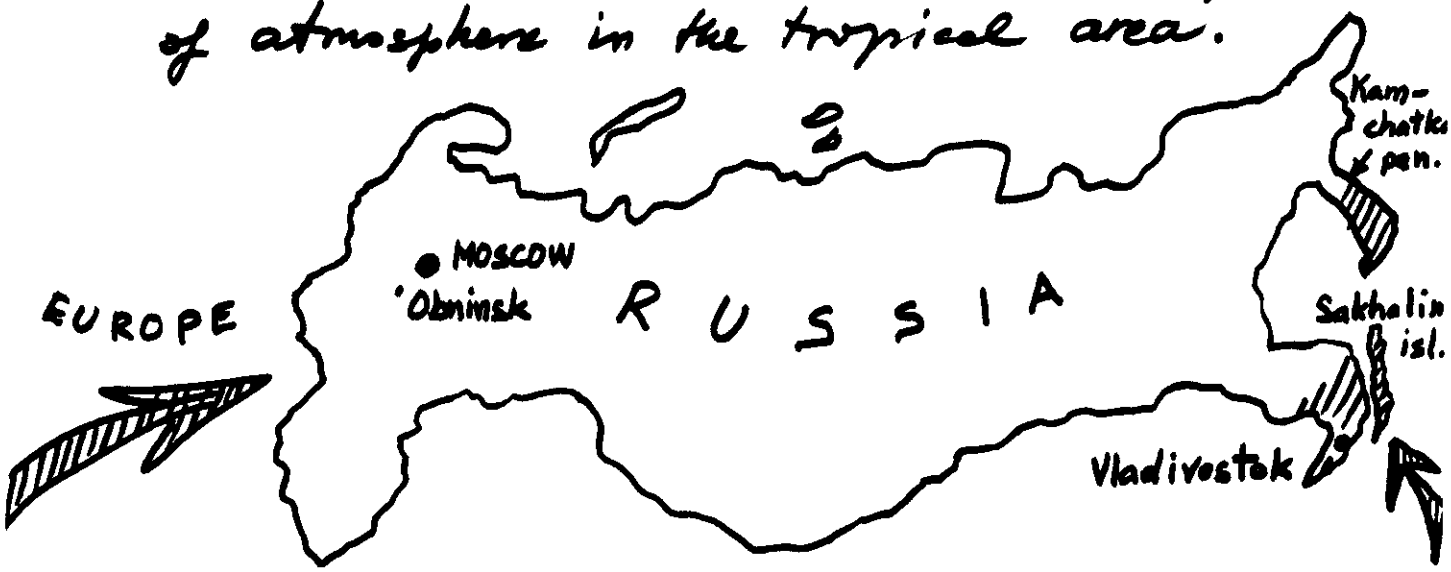
ESSENTIALLY TROPICAL LAM STUDIES WILL BE COVERED IN THE GIVEN PRESENTATION BUT SOME ACCOMPANYING INVESTIGATIONS WILL BE TOUCHED UPON TOO.

(2.) The use of LAM's for study of typhoons/hurricanes

- Some important examples have already been given by Prof. Y. Kurihara in his lecture on hurricane modelling.
- Both LAM's and global (hemispherical) models are presently used for T/H studies and predictions. The most well-known LAM's (in addition to GFDL/NCEP model) are models of JMA, BMRC. Global forecasting is carried out in the ECMWF.
- "Nested grids" concept is common while using the above and some other models. Time-dependent lateral boundary conditions lie the inner grids with the external (e.g. global) one. Time-step near T/H may be as small as 25-40 km.
- The "spin-up" problem arises when inserting an idealized T/H vortex into the large-scale fields. This can be solved by quite different ways, 2-dimensional vs. 3-dimensional spin-ups may be quite different approaches.
- The latest tendencies in modelling T/H motion (and, sometimes, evolution) include so-called ensemble forecasting. Examples are FSU, NCEP as well as the Hydrometeor. Centre of Russia.
- Simple barotropic (shallow-water) models are still successfully applicated to forecasting T/H tracks what is essential for developing countries with their limited computer facilities.

(3.) The use of LAM's for T/H forecasting in Russia

The main part of studies is carried out in the Hydrometeorological Research Centre of Russia (Moscow), in the Lab. of the dynamics of atmosphere in the tropical area.



Other institutes are the Institute of Experimental Meteorology (Obninsk, near Moscow), The Far-East Regional Research Hydrometeorological Institute (Vladivostok, on the Pacific Coast, Japan Sea).

(There is a booklet on their activity)

All the above institutes belong to Russian Federal Service for Hydrometeorology and Environmental Monitoring (Roshydromet).

In addition, some theoretical and climatic studies are carried out in the Institute of Atmospheric Physics (Russian Academy of Sciences) and at the Geographical Faculty of the Moscow State University (Chair of Meteorology and Climatology).

• Models developed in the Hydrometeorological Research Centre of Russia (Moscow)

1. Barotropic (Shallow-water) and equivalent-barotropic models

- The former one is in the operative use for the typhoons of the western North Pacific (north to 15°N) since 1988; the latter one is being operatively tested. The shallow-water eqs. are used, the lateral boundary conditions are time-dependent and defined from a hemispherical finite-difference model. A typhoon is given initially by its radial profile of V_θ, maximum velocity V_{max} and its radius R_0. The balance equation is used in the surroundings of a typhoon to define the height field. The space increment near typhoon is about 60 km.
- The forecasts are calculated up to 72 h. The value of the mean position error of a typhoon in a 24h forecast is 200-250 km if the objective analysis produced in the Hydrometeorological Centre itself is used and is about 150 km if an analysis transmitted over GTS from Washington and Reading in the GRID code is used.

2. 10-level baroclinic model

- Presently a "research version" is used. Non-adiabatic processes are represented by a "heating function". A "spin-up" procedure has been developed at $t = t_0$. Some numerical experiments have shown that a maximal time-step for baroclinic models in the typhoon surrounding is about 30-40 km.

- Numerical experiments on the interaction of binary and multiple vortices

They are described in more details in the lecture by Dr. A. Pokhil and here will be touched upon only briefly.

The "historical source" of such experiments is the Fujiwhara effect (1922). For last 10-15 years many studies have been undertaken in different countries (USA, Australia and others). The importance of the problem is that vortex interaction leads often enough to the appearance of unusual T/H tracks which are badly predictable.

The most part of our experiments has been conducted with idealized vortices embedded in the zero external field or linear one. However, some experimentation has been made with real typhoons and their pairs (triplets). Some critical parameters have been obtained defining whether vortices will attract each other or repulse. A mechanism of formation of a large vortex from several small ones has been clarified.

- Motion and evolution of a single and binary tropical cyclones in a coupled "atmosphere-ocean" numerical model

These experiments have begun in the former USSR (The Hydrometeorological Centre, in particular) and continued in the USA and Israel. The impact of the TC-ocean interaction on the evolution and trajectory of 2 TC's has happened to be much stronger than in the case of a single TC.

Conclusions

Our experience has shown that even rather simple models may be productive for prediction of T/H tracks. The effect of interaction between several vortices, on one side, and interaction of one or a pair of vortices with the ocean helps to create much more realistic view on behaviour of real tropical cyclones.

Perspectives :

- further improvement of existing LAM's for forecasting T/H tracks ;
- development of dynamical-statistical models aimed at the same task ;
- development of simplified versions of our models to be used in the countries with worse computer facilities or, as an example, in the field conditions (say, on board a research ship) ;
- development of ensemble forecasting tropical cyclone tracks (and evolution);
- the use of the supercomputer CRAY Y-MP recently installed in the Hydrometeorological Centre of Russia.

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