

meeting summary



Proceedings of an International Workshop on the Dynamics and Forecasting of Tropical Weather Systems

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1. Introduction

There has been much progress in recent years in understanding the large-scale dynamics of the tropical atmosphere on intraseasonal and longer timescales. With the exception of tropical cyclones, however, there has been rather less focus on the morphology and dynamics of tropical weather systems that are important in day-to-day weather forecasting, including monsoonal weather. Thus, skill in forecasting in the Tropics has lagged behind that in midlatitudes, and current weather forecasts in the Tropics have modest credibility, at best, with users. Forecasters in tropical regions have few conceptual models at their disposal and there is a notable lack of useful theory on which they can call. Moreover, numerical weather prediction in the Tropics is often of limited value for forecasting weather involving convection, probably because of the paucity of appropriate mesoscale observational data and the limitations of both current initialization procedures and physical parameterizations. The situation will be rectified only with improved theoretical understanding, the consequential development of better forecasting techniques, and the transfer to forecasters of both understanding and techniques.

Although there have been some improvements in the situation over the years, there seemed an urgent need for a forum in which forecasters can come together with researchers to make more rapid progress on this problem. As a start, a group of forecasters and researchers with a commitment to tropical meteorology met in Darwin, Australia, from 22 to 26 January 2001 to discuss the current shortcomings and ways in which progress could be accelerated, particularly to the advantage of the many developing nations in the Tropics. The participation of forecasters was sponsored by the Australian Bureau of Meteorology (BoM) and the World Meteorological Organization (WMO); researchers funded themselves.

2. Meeting format and presentations

a. Format

A number of forecasters from offices responsible for tropical weather prediction were invited to articulate their problems and a number of leading atmospheric dynamicists sought to review the state of knowledge relevant to tropical weather forecasting, including the special requirements of numerical weather prediction. The meeting was restricted in size with mainly invited talks and provided a generous amount of time for discussion. The aim was to stimulate more research that is focused on relevant forecasting problems in tropical regions. The format proved to be very successful. A Web site containing the meeting report and papers has been established at <http://www.bom.gov.au/weather/nt/inside/workshop/index.html>, and a workshop proceedings volume is in preparation.

Participants comprised 15 research scientists from the United States, Australia, China, and Germany; eight forecasters from Fiji, Malaysia, Philippines, Singapore, Thailand, United States (Miami, FL, and

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Guam), and Vietnam; and 20 Australian tropical forecasters (including two instructors from the BoM Training Centre, Melbourne). The workshop was officially opened by Mr. Jim Arthur (Regional Director of the Northern Territory Regional Office, BoM, Darwin), Dr. Mike Manton [Chief of the Bureau of Meteorology Research Centre (BMRC), Melbourne, Australia], Prof. Bruce Morton (Monash University, representing the Australian Meteorological and Oceanographic Society, Melbourne, Australia), and Prof. Roger Smith (University of Munich, Germany).

b. Forecaster presentations

The opening presentation by Dr. Roger Atkinson (BoM, Darwin) set the Australian scene by reporting on the results of a survey of 36 BoM tropical forecasters in the Northern Territory, Queensland, and Western Australia. A very wide range of forecast problems and their causes was identified, and a large number of areas for future research suggested. Mr. Frank Wells (National Weather Service, Guam) documented several weather situations over the western North Pacific Ocean that require better understanding in order to improve the skill of forecasts. Dr. Lixion Avila (National Hurricane Center, Miami, FL) similarly described current forecasting difficulties over the North Atlantic and Caribbean associated with events other than tropical cyclones, and Ms. Vive Bukoto (Fiji Meteorological Service) spoke of short-term forecasting problems associated with tropical weather systems in the large Fiji area of responsibility. Dr. Wan Azli Wan Hassan (Malaysian Meteorological Service) presented two case studies showing the difficulties of forecasting heavy or extreme rain episodes in Malaysia. Mr. Ellaquim A. Adug (Philippine Atmospheric Geophysical and Astronomical Services Administration, Manila) comprehensively documented the major tropical wind and rain systems affecting the Philippines including case studies of unusual but recurring and difficult rainfall situations. Mr. Le Thanh Hai (National Center for Hydrometeorological Forecasting, Hanoi, Vietnam) spoke on the use of numerical weather prediction products for short-range operational weather forecasts in Vietnam, focusing on two flooding events. Ms. Lori Chappel (BoM, Darwin) discussed the problems of anticipating tropical thunderstorm types in northern Australia and assessing their potential to be severe from a knowledge of the environmental low–midlevel wind shear and the convective available potential energy from a modified radiosonde sounding. Mr. Jeff

Callaghan (BoM, Brisbane) talked about the role of convection and thermal structure on the development of severe tropical lows over the Coral Sea and southwest Pacific Ocean, and associated warning strategy problems. Mr. Choo Huat Aik (Singapore Meteorological Service) discussed weather forecasting problems in Singapore with an emphasis on impacts of severe weather systems producing heavy rainfall. Mr. Prawit Jampanya (Thai Meteorological Department, Bangkok) gave an overview of weather forecasting in Thailand and detailed some significant weather situations that cause forecast difficulties in the region. Mr. Mark Kersemakers (BoM, Darwin) presented a case study on the forecasting aspects of a tropical disturbance embedded in late wet season easterly flow in the low–midlevels. The disturbance was responsible for severe weather over northern Australia and adjacent waters, but did not follow any standard conceptual model.

An interesting result of the forecaster presentations was the wide commonality of forecasting problems confronting tropical meteorologists. Rainfall, in particular, was regarded as difficult to forecast, the most extreme rainfall events being associated with westward-moving disturbances, the position and movement of the monsoon trough or the ITCZ, and/or interactions with midlatitudes such as winter monsoon surges.

c. Researcher presentations

The researcher presentations covered three main areas: tropical waves, convection, and numerical weather prediction. In the talks on tropical waves, Dr. Matthew Wheeler (BMRC, Melbourne) delivered a review of “synoptic to intraseasonal” tropical wave modes with relevance to forecasting, which can be diagnosed and extrapolated in semi-real time by filtering time–longitude series of satellite-sensed outgoing longwave radiation. Dr. John Molinari (State University of New York at Albany, NY) presented results of low-pass- and bandpass-filtered wind analyses over the western Pacific that appeared to show coherent tropical wave modes that grow within the active period of the Madden–Julian oscillation and are consistent with linear theory. Dr. Adam Sobel (Columbia University, NY) presented a fascinating animation of color enhanced satellite imagery spanning several months over the field of view of the Japanese Geostationary Meteorological Satellite *GMS-5*. In the talks on the structure and prediction of convection, Prof. Dave Raymond (New Mexico Tech., Socorro,

NM) hypothesized that the distribution of tropical maritime convection depends on local forcing, that is, local profiles of temperature, moisture and horizontal wind, and local surface and tropopause fluxes, rather than the nonlocal (large scale) influences of convergence and vertical motion. Dr. Brian Mapes, (National Oceanic and Atmospheric Administration–Cooperative Institute for Research in Environmental Sciences Climate Diagnostics Center, Boulder, CO) discussed the representativeness of radiosonde soundings in a convective environment, the influence of convective inhibition and convective available potential energy in controlling convection, and effects of entrainment. Prof. Bruce Morton gave an historical overview of turbulent plumes and observational laboratory evidence for the nature of entrainment. In talks on the use of numerical models, Dr. Noel Davidson (BMRC, Melbourne) gave a comprehensive overview of the status, problems, and prospects of operational numerical weather prediction in the Tropics; and Prof. Roger Smith (University of Munich) reported on a continuing study of high-resolution numerical model predictions of cloud lines over the Gulf of Carpentaria.

3. Meeting outcomes

a. Recommendations

The meeting identified two areas of need:

- To improve the application of science in forecasting offices and bring to forecasters an understanding of recent research developments; and
- To facilitate research by bringing researchers into forecast offices so that they are more widely aware of the special difficulties in tropical meteorology and accept the challenge of the many pressing forecasting problems in the Tropics.

Although there has been much good work in tropical meteorology research, there would be a considerable benefit from an improved theoretical understanding and numerical modeling as has already occurred in midlatitudes, especially improvements in the initialization of numerical weather prediction models in the Tropics. Accordingly, the meeting made four recommendations:

1. That the WMO and National Weather Services provide funding to encourage researchers to spend periods of time in forecasting offices to interact

with forecasters and familiarize themselves with the scientific problems of forecasting in the Tropics.

2. That WMO support the compilation of an evolving document encapsulating the state of knowledge of tropical meteorology as it relates to operational weather forecasting on timescales of hours to days. This should be available in electronic form and complement existing publications on tropical cyclones.
3. That WMO support further workshops on tropical weather forecasting that bring forecasters and researchers together.
4. That WMO and National Meteorological Services take urgent steps to improve the transfer of advances in theoretical understanding and forecasting techniques to forecasters by continuing in-service and specialist training.

b. Promotion of information transfer between forecasters and researchers

Experience has shown us that forecasters who have been through even well-regarded training programs may have relatively little exposure to tropical meteorology and tropical forecasting. For example, a 10-month training course given by one major national weather service includes no more than 25 hours of lectures on tropical meteorology and forecasting. Although practical experience is built up after posting to tropical offices, there is no further formal exposure to theoretical aspects. In such circumstances training course graduates may lack the understanding and confidence to make full use of some well-established and many new theoretical ideas, and may be uncertain of their application to forecasting. Better in-service training is needed, and beyond that we need to build an interactive community of forecasters/researchers who are able to exchange ideas with confidence and develop the habit of listening to each other. This process is under way, but still has far to go.

The meeting considered ways to promote the transfer of information between forecasters and researchers and suggested the following ideas:

- (i) establish an e-mail discussion group and possibly a Web site (perhaps with WMO endorsement);
- (ii) ask forecasters to flag interesting/important observed cases, noting the nature of the event to alert researchers to cases for possible study;
- (iii) ask researchers to flag interesting new results in terms accessible to forecasters;

- (iv) encourage forecasters to document their techniques and rules of thumb;
- (v) commission researchers to write articles on phenomena and issues in language intelligible to forecasters;
- (vi) encourage WMO and National Weather Services to fund visits of researchers to forecast offices for immersion in the culture/science of forecasting, not procedures;
- (vii) identify forecast offices as possible sites for study leave;
- (viii) establish programs that foster collaborative research;
- (ix) encourage universities and atmospheric research organizations to send seminar speakers to forecasting offices to engage forecasters on interesting/difficult problems;
- (x) organize more seminars in which researchers present theories and forecasters discuss cases to mixed forecaster/researcher audiences;
- (xi) advertise seminars to a wider audience and distribute video tapes of these on request;
- (xii) make better use of video conferencing techniques as these are developed to increase exposure of distant groups to appropriate seminars/discussions;
- (xiii) run a workshop program;
- (xiv) develop the idea of mentors, as researchers who will accept continuing responsibility for liaising with groups of forecasters.

c. *Future action*

The meeting established a steering committee to coordinate the following actions arising from the workshop:

- establish an e-mail discussion group (and possibly other electronic forums) on tropical weather to facilitate communication among research scientists and forecasters;
- select organizers, subjects, and formats for future meetings on tropical weather forecasting and related problems;
- support the pilot use of mesoscale numerical models in forecasting offices; and
- select a group of editors for the evolving document on the state of knowledge of tropical meteorology and forecasting subject to financial support.

The current composition of the steering committee members is listed in the appendix.

d. *Themes for future workshops*

The attendees felt that this workshop had been highly effective and that such workshops should form an important component of any plans for the future. It was the view that workshops should be strongly focused and yet broad enough in subject for positive involvement of a sufficient group to yield diversity of view. They should be run primarily by enthusiasts rather than committees and at technical levels within reach of forecasters. Some could be built on events flagged by forecasters. Workshops should adopt a range of formats such as morning talks and afternoon exercises, or morning talks and afternoon chart discussions. They should be held near forecast offices to allow more forecasters to participate, should allow plenty of time for discussion, and should avoid the conference format of large numbers of short talks. The following topics were selected as important ones requiring additional research and as possible themes for future workshops:

- NWP initialization and parameterization of diabatic processes;
- synoptic-scale tropical waves and disturbances;
- regional numerical weather prediction, especially for developing countries;
- forecasting convection;
- trade wind surges/perturbations;
- life cycles of monsoon depressions;
- hybrid tropical–midlatitude systems;
- the utility of potential vorticity in the Tropics;
- subtropical–tropical interactions;
- large-scale circulation changes in the Tropics (e.g., monsoon onset);
- Madden–Julian oscillation;
- role of topography;
- forecasting water substance (rainfall, dewpoint, ground moisture);
- the limits of predictability in forecast skill;
- probability forecast methods based on models and/or archived radar data.

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The participation of the third author, (JM) was supported by the same organization through Grant N00014-98-0599.

Appendix: The Steering Committee Membership

- Prof. Roger Smith, University of Munich, Germany (chair)
- Dr. Roger Atkinson, Bureau of Meteorology, Darwin, Australia
- Dr. Lixion Avila, National Hurricane Center, Miami, Florida
- Ms. Duong Lien Chau, National Centre for Hydrometeorological Forecasting, Hanoi, Vietnam
- Dr. Noel Davidson, Bureau of Meteorology Research Centre, Melbourne, Australia
- Prof. Kerry Emanuel, Massachusetts Institute of Technology, Cambridge, Massachusetts
- Mr. Geoffrey Garden, Bureau of Meteorology, Darwin, Australia
- Dr. Tom Keenan, Bureau of Meteorology Research Centre, Melbourne, Australia
- Dr. Brian Mapes, Climate Diagnostics Center, Boulder, Colorado
- Dr. John Molinari, State University of New York at Albany, Albany, New York
- Prof. Dave Raymond, New Mexico Tech, Socorro, New Mexico
- Dr. Michael Reeder, Monash University, Melbourne, Australia
- Dr. Chris Thorncroft, State University of New York at Albany, Albany, New York
- Mr. Frank Wells, National Weather Service Forecast Office, Guam
- Dr. Wan Azli Wan Hassan, Malaysian Meteorological Service, Kuala Lumpur, Malaysia
- Dr. Joe Zehnder, Arizona State University, Tempe, Arizona