EIGHTH INTERNATIONAL WORKSHOP ON TROPICAL CYCLONES

**Topic 2: Cyclogenesis, Intensity and Intensity Change**

- **Topic chairs:**
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Overview

- Cyclogenesis and intensity change forecasts still remain a significant challenge.

- The IWTC-VII in 2010 recommended:
  - standardizing metrics used for genesis and intensity across RSMCs
  - validating basin-specific Dvorak estimates with available data
  - further development of both satellite-based and probabilistic techniques to estimate and predict formation and intensity.
  - Further research into the basic processes underlying both genesis and intensity change including rapid intensity change
  - Research into the predictability limits for intensity forecasting
  - the expansion of, and training in, forecast aids from the Atlantic basin to the remainder of the global TCWCs
Overview

• This report provides an overview of recent advances in basic research and forecasting perspectives.

• Here we will summarize the successes and challenges that arose from the Rapporteur subtopic reports and highlight some overarching questions and recommendations from this topic.
Topics 2.1 and 2.2: Cyclogenesis – research and operations

• Numerous papers published on cyclogenesis since IWTC-VII.
• continues to be discussed as a multi-scale process where factors from the large-scale to the convective scale cooperatively interact to develop the initial TC
• Unlikely that NWP global models will reach a resolution to properly predict the inherently stochastic processes associated with convection.
• If the pre-cursor waves could be forecast (with demonstrable skill), then genesis could be forecast.

(Adapted from Dunkerton et al. 2009)
Topics 2.1 and 2.2: Cyclogenesis – research and operations

• Since ITWC-VII, several RSMCs/TCWCs have begun to issue either qualitative or probabilistic genesis forecasts to the general public.

• Dramatic improvements have occurred in both the skill and the lead time of genesis forecasts
  – primarily due to the increased capabilities (resolution) of global models
  – also new statistical, statistical-dynamical hybrid, and EPS approaches are leading to more confidence in the issuance of genesis predictions
The outstanding research questions posed in IWTC-VII have not changed.

- The “debate” on the relative roles of mesoscale/convective properties, processes, and evolution continues - what is required to conclude the debate within the next four years? Should the debate end?
- Are advances in genesis understanding translating to improved prediction of genesis or is the improvement in forecasting genesis serendipitous because of model improvements? Does it matter?
- Does this mean the importance of the synoptic scale overrides that of the mesoscale or will the models bust on predicting genesis when convective processes dominate a genesis event?
- What is the limit of predictability? Is it predicting convection?
- What is the next step in genesis forecasting? Is it issuance of watches and warnings before genesis has even occurred? Would forecasters dare to do that? What is the value in doing that?
Topics 2.3 and 2.4: Satellite analysis of TCs

• A number of methods to perform objective analysis of TCs have been developed.

• Operational use of these techniques has been steadily increasing (more operational centers adopting the techniques).

• Types of analysis include:
  • **Intensity estimation**. Several techniques exist with skill that matches and in some cases exceeds that of the original subjective Dvorak technique.
  • **Surface wind field estimation**. Only a very few techniques exist and there is only one operationally-implemented technique.
  • **Center-finding algorithm** (ARCHER)
Topics 2.3 and 2.4: Satellite analysis of TCs

- Objective methods provide inputs to the final TC intensity estimate.

- Many other factors are taken into account including: other sources of measurements (e.g., scatterometry, buoy, aircraft, ships); subjective pattern analysis; and NWP model input.

- The weighting of the various inputs and the expertise of the analyst will all play a role in the final intensity estimate.
Topics 2.3 and 2.4: Satellite analysis of TCs

• The 1st WMO international Workshop on Satellite Analysis of Tropical Cyclones (IWSATC) was held in Hawaii in 2011.

• educated the various TC warning agencies regarding the latest research efforts to objectively estimate TC intensity, and to promote analyst feedback regarding suggestions and modifications of these methods

• One outcome was the development of a COMET training module addressing both subjective and objective TC analysis by J. Courtney (BoM).
Topics for Discussion and Recommendation 2.3 and 2.4

Challenges/Outstanding Issues:

1) Discrepancies among agencies in their intensity estimates of the same circulation using essentially the same sources of information:
   - Should agencies standardize their methodologies and metrics or at least benchmark them against some agreed-upon standard?
   - Should agencies share their methodologies?
2) Changes in satellite sensors and other types of new datastreams means that techniques utilizing those measurements and guidance on their use must be continuously updated/improved:

- Continuous development of techniques to ensure errors are not introduced from new sensors
- Sharing of validation-quality data so that techniques can be developed, tested, and utilized in all basins
- Ongoing training sessions such as those run under the auspice of WMO and sharing of training materials
- Regular updating of the COMET module recently developed in collaboration with BoM in response to the IWSATC (2011) workshop. This is an ongoing process for which someone/s should have identified responsibility
3) The Dvorak Technique does not perform so well on more unusual TC structures:
   - Monson gyre development
   - Extratropical transition
   - Small/midget tropical cyclones
   - Systems over land
   - Secondary eyewall formation

• **Improve/develop techniques for these cases:**
  - Requires larger sample sizes with high-quality validation data
  - Research to understand how best to apply techniques for these cases
Topics 2.5-2.7: Intensity change – research and operations

• Since IWTC-VII continued progress on basic understanding of the environmental and internal influences on TC intensity has been made. However, improvements in 24-48 hr intensity forecasts persist in lagging behind their counterpart track forecasts.

• Studies have further examined the role of the following environmental variables:
  – Vertical wind shear (-)
  – Relative humidity (+/-)
  – SST and OHC (+/-)
  – Upper-level outflow interactions (+/-)
Topics 2.5-2.7: Intensity change – research and operations

- Studies have also examined the role of: aerosols; PV injection from coherent structures evolving within the near-TC environment.

- Factors associated with rapid intensification and rapidly weakening cases have also been studied – difficult to separate environmental factors for rapid intensification versus normal intensification

Operational challenge: to sort out competing environmental influences on intensity change – research indicates that they are important – but it is not clear how to weight individual factors operationally.

Source: NRL
Topics 2.5-2.7: Intensity change – research and operations

- Internal factors for TC intensity change that have been studied include:
  - Distribution of inner-core convection
  - Eyewall replacement cycles
  - Outer rainbands
  - Eyewall instability and inner-core mixing
  - Air-sea interactions

- Can these advances in basic knowledge be translated into tools for operations? While there may be resolution and other limits on NWP models for accurately simulating inner core processes, already developing probabilistic forecast techniques for secondary eyewall formation; eyewall replacement cycles; and annular TCs
Since the IWTC-VII there has been considerable effort focused on improving tropical cyclone intensity forecasts, with much of that effort on improving NWP models.

While intensity forecast errors themselves have seen little improvement over the last 4 years, there is evidence that intensity forecast guidance is improving.

Consensus and probabilistic guidance for intensity are now being developed and used operationally.
Topics 2.5-2.7: Intensity change – research and operations

• A recommendation from IWTC-VII was that forecast aids from the Atlantic basin should be developed for, and implemented in other RSMCs
  - Guidance available in the North Atlantic and eastern North Pacific basins have been developed for, and made available to, RSMCs in other basins.

• This sharing of guidance has benefited many RSMCs and should be continued
Topics 2.5-2.7: Intensity change – research and operations

**Challenges:**

1) to accurately sort out competing environmental influences on intensity change – research show that they are important – but it is not clear how to weight individual factors operationally.

2) sort them out from internal influences

3) Clearly continued research into basic processes associated with internal influences on TC intensification is required

4) Continued development of techniques that utilize the advances in understanding both external and internal influences on intensity

5) To identify whether improved understanding will translate into improvements in NWP models – or is intensification due to internal processes inherently unpredictable at least by NWP?
Topics for Discussion and Recommendation 2.5-2.7

• What factors are more important for an intensity forecast? Environmental factors? Internal factors? How would you work out how to weight the various factors?

• Has the guidance for intensity forecasting improved in your operational center? If so, what were the main factors that caused that improvement? Improved NWP guidance? New products?
Recommendations

• **Objective satellite-based techniques for tropical cyclone intensity and wind field estimation** should be calibrated for, and made available to, operational centers in all TC basins.

• **Continuous updating and sharing of training materials** for objective and subjective TC analysis should remain a priority within WMO.

• **Sharing of techniques, information, metadata, and observations/model forecasts** among all operational centers should be encouraged.

• **Encourage continued research of the multi-scale, processes occurring during tropical cyclogenesis** with a view to improving genesis forecasts.

• **Encourage research activity to investigate all influences on TC intensity change** with a view to improving intensity forecasts.

• **Continued development of NWP models, statistical models, and probabilistic guidance for genesis and intensity** should remain a priority.
Thank you

Topic chairs
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