NATIONAL ACADEMIES Sciences Engineering Medicine

Extreme Rainfall in Mountainous Terrain:

Modeling and observational challenges for warm-season precipitation

Session 2 Modeling Extreme Warm Season Rainfall in Mountainous Terrain - Summary Observations and Highlights

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Session 2: Summary Observations on Modeling

- *Mesoscale Convective Processes are crucial to modeling extreme short-duration precipitation*
- *Models useful to understand rainfall from storm cells*
  - *Synoptic/mesoscale – storm cell enhancements*
  - *Storm cell initiation, anchoring and enhancement in terrain*
- *Modeling Low-level flow, Microphysical Processes, and Vertical structure are necessary for estimating warm-season extreme precipitation in mountainous terrain*
- *Convective Parameterization schemes (Microphysics) have shortcomings*

Session 2: Summary Observations on Modeling

- ***Climate-scale Convection-Permitting Models (CPMs) are a sound approach to PMP estimation***
- *Given limitations in observations, transposition, and model evaluation, km-scale CPM ensembles may already be good enough to contribute to PMP estimates*
- *CPMs still have challenges, such as*
  - *Lack meso-to-microscale terrain variations that may anchor and fuel the convection*
  - *Uncertain subgrid parameterizations*
- ***Challenges can be addressed through PMP Model Evaluation Project***

Session 2: Summary Observations on Modeling

- *Ensembles of Large Eddy Simulations (LES) of Precipitating Clouds*
  - *Past Extreme Rainfalls with Actual Orography*
  - *Possible Synoptic/Thermodynamic Environment(s) in Future Climate*
- ***LES can help to critically evaluate parameterization schemes and refine approach***
- *Simulate recent extreme cases and non-extreme cases that present similar environmental conditions*
- *Can strengthen confidence in CPM approach and/or pinpoint critical model biases*
- *Can be used to train emulators for fast parameterizations and generating ensembles*

Session 2: Highlights for Future Work - Modeling

- ***Historical development of PMP methods are rooted in Forecasting theory and efforts of extreme precipitation***
  - *See Appendix B in Modernizing PMP report – details*
- ***Increased Collaborations between Forecasting Model Developers and Extreme Applications***
  - *Model improvements for **both** Forecasting and PMP Applications*
  - *Improve Operational Forecast Models developed at NOAA Research Labs (Physical Sciences Lab, Global Systems Lab), NCAR, and others*
  - *HRRR, GFS, UFS, WRF/MPAS*
- ***Model Evaluation Project***