Quantifying and Comparing the Intensification of Extreme Rainfall Frequency from NCEP and ERA40 Reanalysis Data

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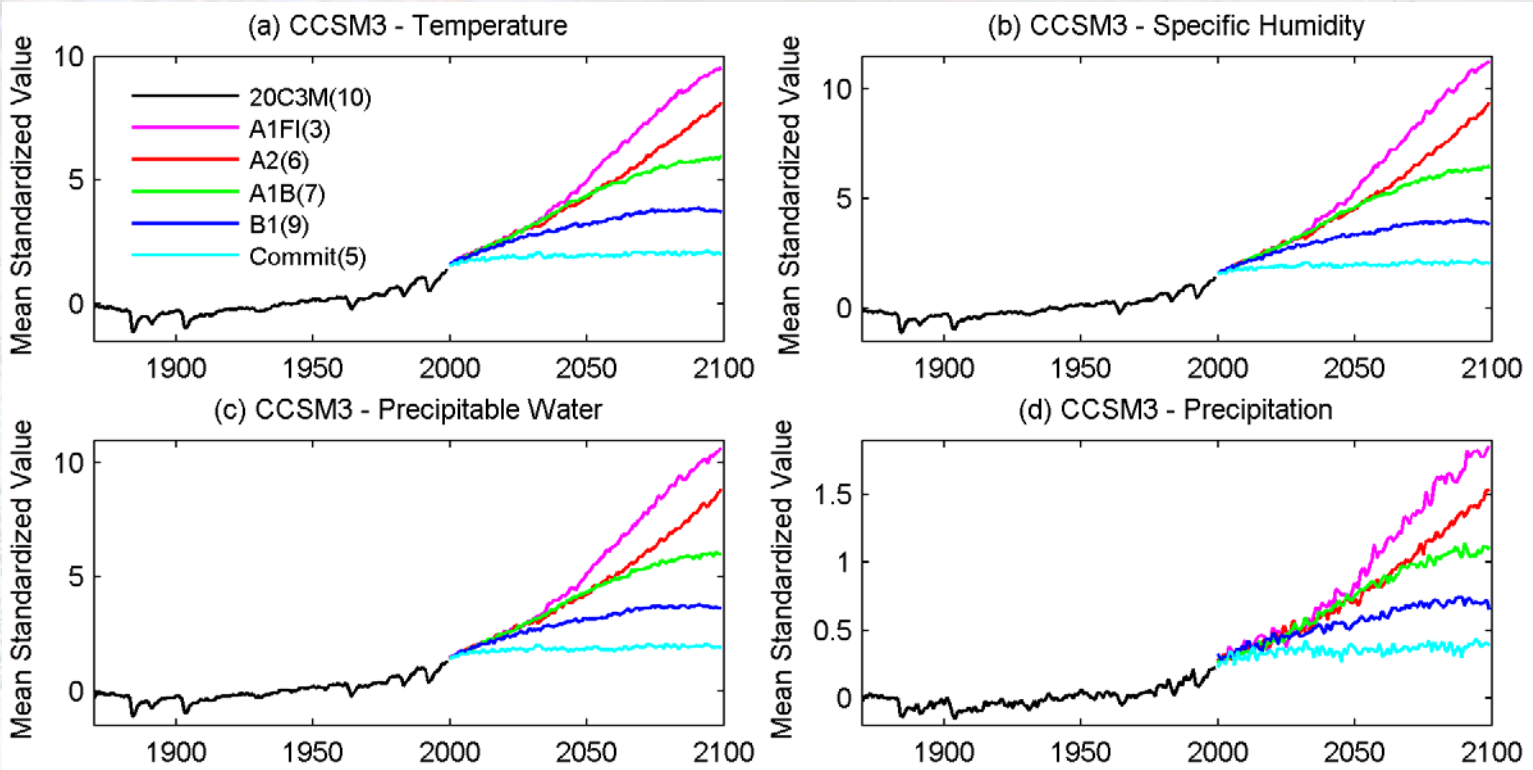
Background and Motivation

Geographic Information Science and Technology

- **Warming climate and intensified rainfall extremes (IPCC AR4, 2007)**
  - **How to interpret it in terms of hydraulic/hydrologic engineering design concept (recurrence interval)?**
- **Challenges**
  - **Scale and resolution**
  - **Inconsistence among different climate models**
  - **Scientific understanding**
  - **Limited (in time) observational dataset to verify**
- **Potential impacts**
  - **Most structures are designed based on thresholds developed under stationary assumption**
- **More thorough examination toward rainfall extremes**

From Temperature to Precipitation



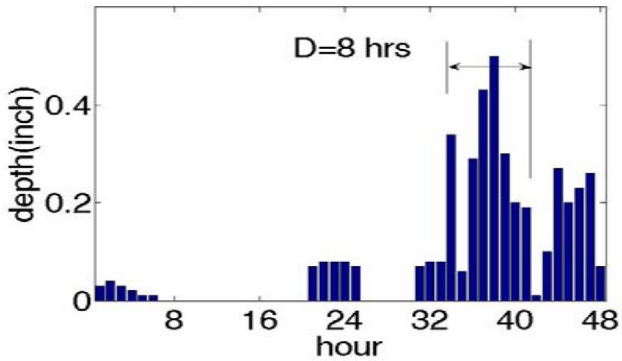
- **Clausius-Clapeyron relationship**
  - **temperature => humidity => precipitable water => precipitation => surface hydrology**
  - **Non-stationary**
- **How to quantify the change in frequency?**

Reanalysis and Climate Model Data

- **Features required**
  - Annual maximum rainfall under various storm durations
  - Fine temporal resolution (sub-daily) and global coverage
  - Continuously recorded
- **Meteorological reanalysis**
  - NCEP1: 1948 ~ present, ~1.9˚
  - NCEP2: 1979 ~ present, ~1.9˚
  - ERA40: 1958 ~ 2001, , ~2.5˚
- **Climate projection**
  - 20th Century control run (20C3M, 1900~1999), A1FI, A2, A1B, B1, Commit scenarios (2000~2099)
  - CCSM3, ~1.4˚, 6-hourly data available through ESG
  - CSIRO3.5, ~1.9˚, daily data available through PCMDI

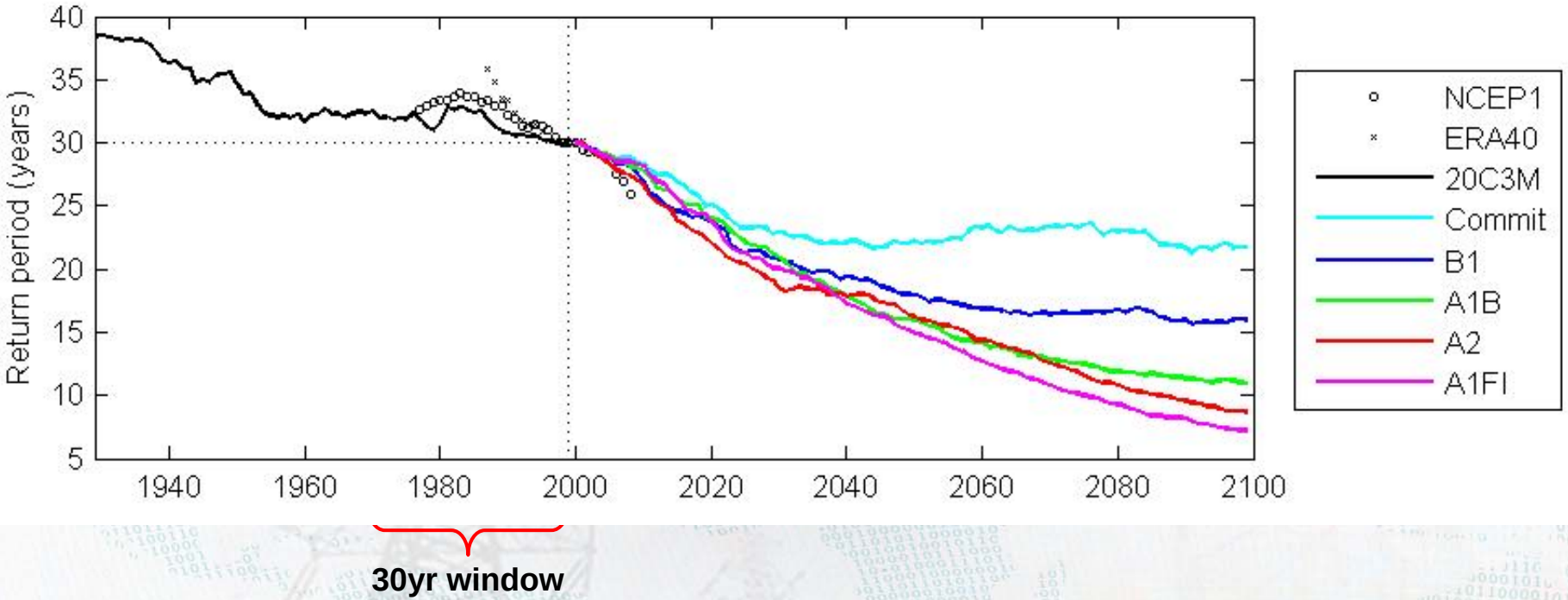
Quantifying the Frequency of Rainfall Extremes

- **Kharin et al (2007)**
  - **Daily and 5-day Precipitation**
  - **20-year window:**
    1981-2000, 2046-2065 and 2081-2100
  - **What is the relationship between rainfall intensity and duration?**
  - **Can we show the continuous change of frequency?**



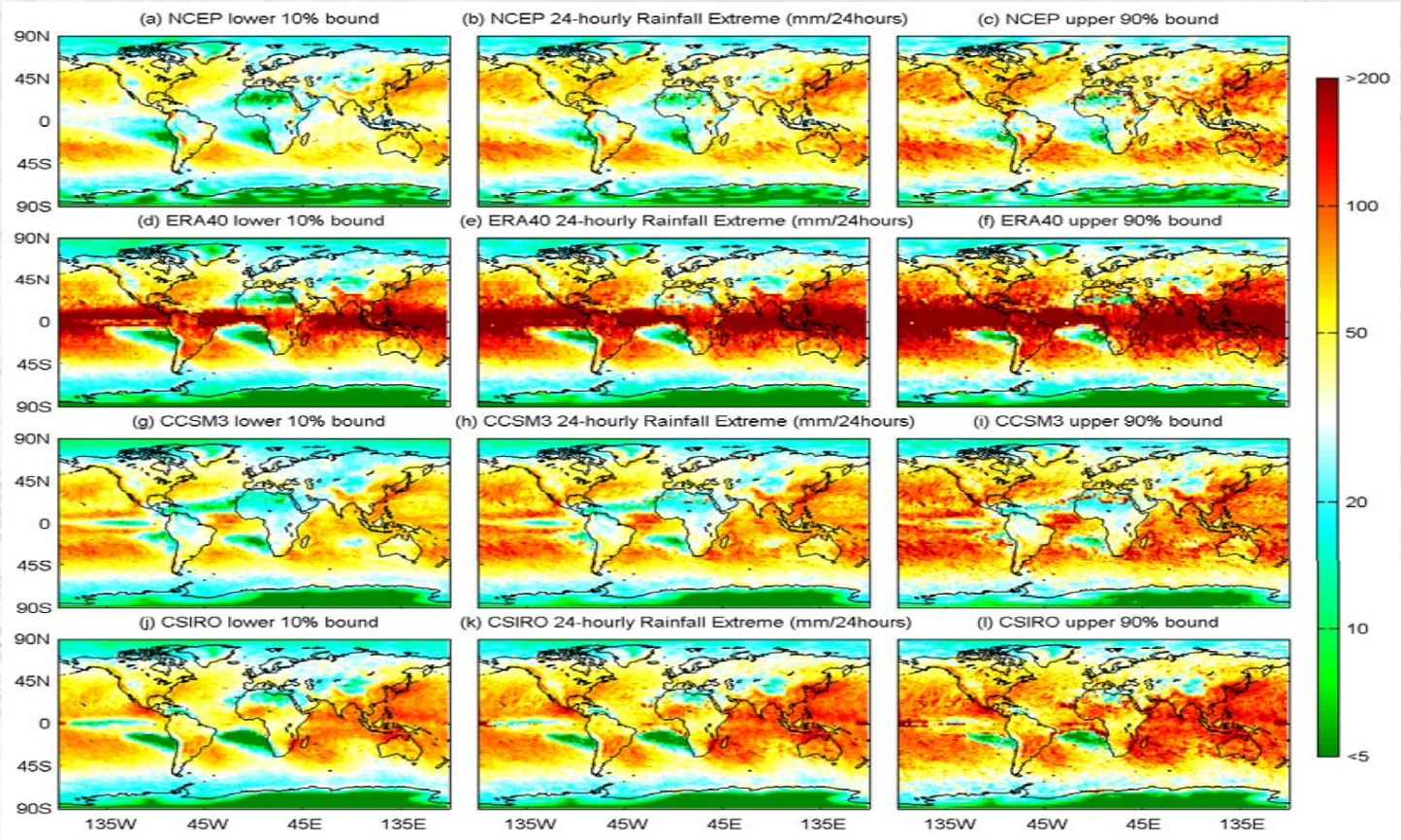
- **Procedures**
  - **30-year moving window**
  - **Compute the 6-, 12-, 18-, 24-, 36-, 48-, 72-, 120-, 240-hour annual maximum rainfall depth**
  - **Generalized extreme value distribution with maximum-likelihood estimators**
  - **Goodness-of-fit test: Kolmogorov-Smirnov, Cramér-von Mises**
  - **3-, 5-, 10-, 30-, 50-, and 100-year recurrence levels**
  - **1000-member bootstrapping uncertainty**

Return Period in the Changing Climate



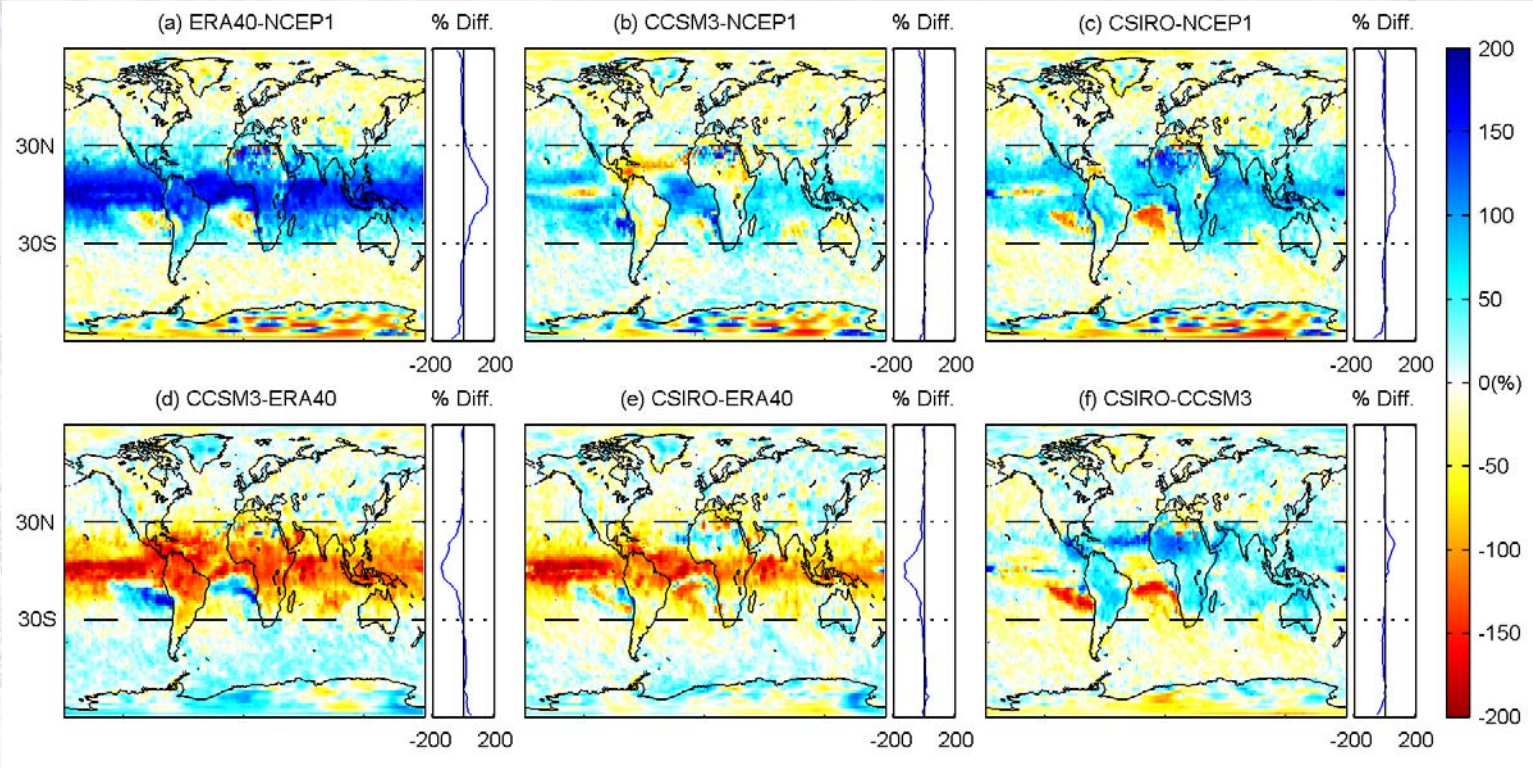
- **Annual maximum precipitation in a 6-hr interval**
- **Median of global return period corresponding to year-1999 estimates**
- **Goodness-of-fit tests at 5% significant level:**
  - **NCEP: 2.56%, ERA40: 1.24%, CCSM3: 0.02%**
- **Consistent trend in the recent two decades**

Estimates/Uncertainty of Rainfall Extremes



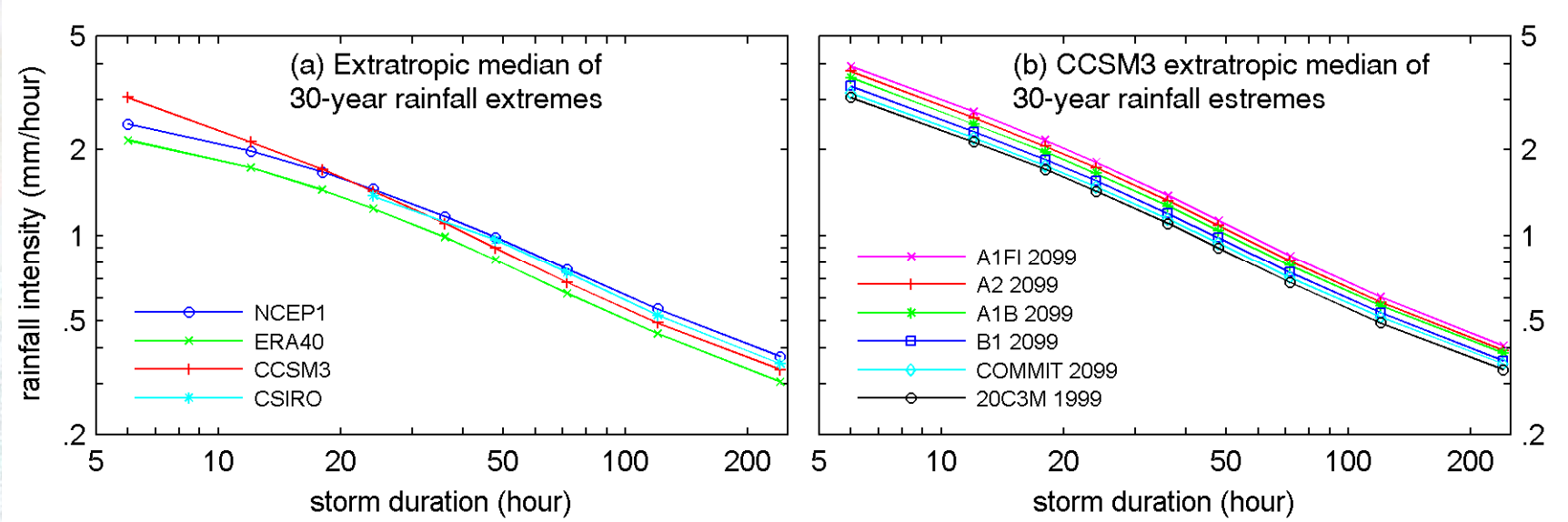
- **Example: year-1999 estimate (1970-1999 data)**
  - **24-hour storm duration, 30-year return period**
  - **Major difference near tropical regions**
  - **Sampling uncertainty seems to be less than cross-model difference**

Difference Between Models and Reanalysis



- **Year-1999 estimate, 24-hour storm duration, 30-year return period**
- **Percentage difference: 100*(A-B)/[(A+B)/2]**
  - **Largest difference between two reanalysis**
  - **High agreement in extratropic regions (90S~30S & 30N~90N)**

Intensity-Duration-Frequency Curves



- **Rainfall Intensity-Duration-Frequency (IDF) relationship**
  - **Can we build IDF curves from climate data?**
  - **Does the linear trend on the log-log plot exist?**
- **Global extratropic median of 30-year rainfall intensity**
  - **IDF relationship basically holds**
  - **Inter-model inconsistency remains the largest difference**
  - **For CCSM3, the year-2099 IDF curves among various scenarios vary proportionally.**
  - **Will the climate safety factor as a possible direction?**

Concluding Remarks and Future Works

- **Interpreting the intensification of rainfall extremes in terms of hydraulic/hydrologic design concepts**
  - **Can we still use return period?**
  - **The potential influence of non-stationarity should be considered.**
  - **Credibility versus risk**
- **The linkage between global and regional trend needs to be built**
  - **Physical mechanism, parameterization, and model resolution**
  - **Consistency among multiple models**
  - **Downscaling with consideration of multi-model inconsistency**
- **Quantify the change of frequency for other hydro-meteorological variables**
- **Trigger of extreme events**

Thank you
Questions?

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