Detection & Attribution and Climate Change Assessments

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Geophysical Fluid Dynamics Laboratory Review

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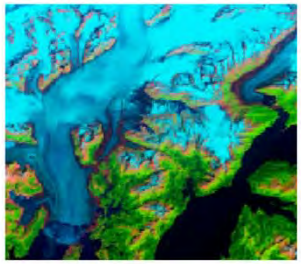
Outline of Talk

- GFDL contributions to Fourth National Climate Assessment (NCA4)
- Regional Precipitation Trends Analysis
- GFDL contributions to new WMO tropical cyclones/climate change assessment

OAR Draft Goals: "Detect Changes in the Ocean and Atmosphere: …identify changes in the Earth System and understand them…"

GFDL contributed significantly to NCA4

Climate Science Special Report
Fourth National Climate Assessment | Volume 1



3 Detection and Attribution of Climate Change

KEY FINDINGS

1. The *likely* range of the human contribution to the global mean temperature increase over the period 1951–2010 is 1.1° to 1.4°F (0.6° to 0.8°C), and the central estimate of the observed warming of 1.2°F (0.65°C) lies within this range (*high confidence*). This translates to a *likely* human contribution of 93%–123% of the observed 1951–2010 change. It is *extremely likely* that more than half of the global mean temperature increase since 1951 was caused by human influence on climate (*high confidence*). The *likely* contributions of natural forcing and internal variability to global temperature change over that period are minor (*high confidence*).

2. The science of event attribution is rapidly advancing through improved understanding of the mechanisms that produce extreme events and the marked progress in development of methods that are used for event attribution (*high confidence*).

NCA4 authors from GFDL:

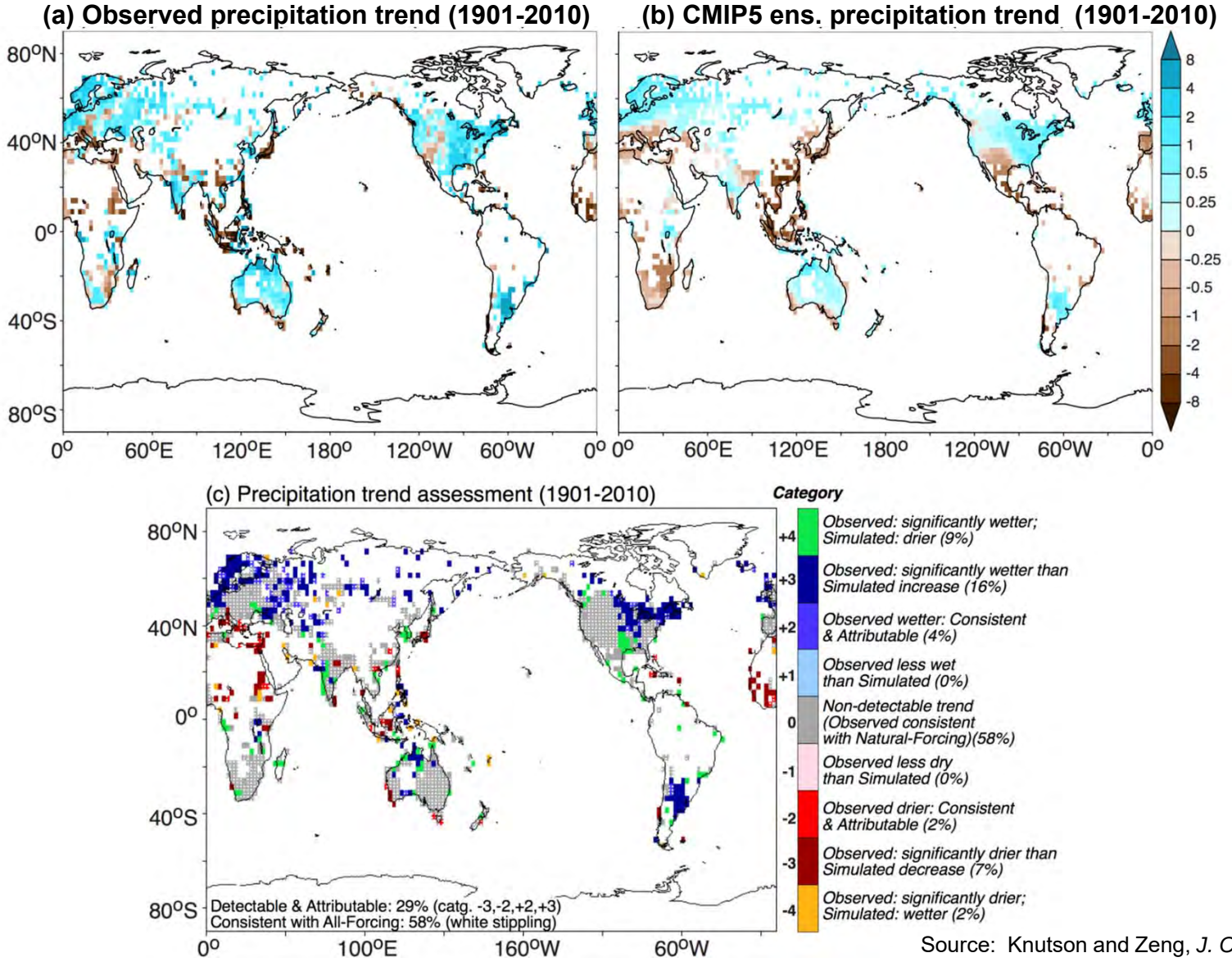
Thomas Knutson: Lead Author on CSSR Chapter 3: "Detection and Attribution of Climate Change."

Charlie Stock: Author on NCA4 Chapter 7: "Ecosystems, Ecosystem Services, and Biodiversity"

Vaishali Naik: Author on NCA4 Chapter 13: "Air Quality"

Larry Horowitz: Author on NCA4 Chapter 13: "Air Quality"

Regional Precipitation Trends: Detectable anthropogenic influence -- mostly increases with some decreases in a few regions

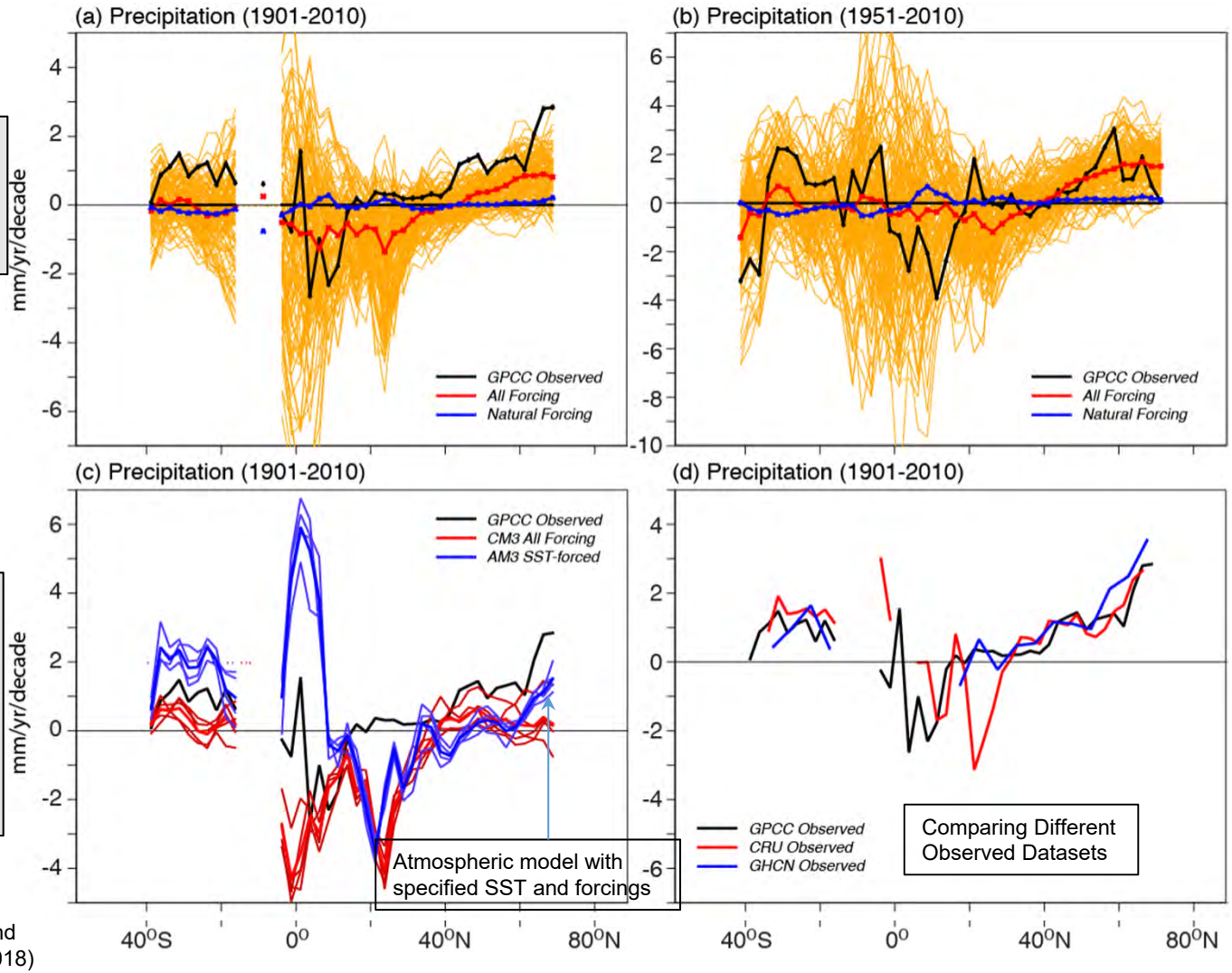


Source: Knutson and Zeng, *J. Climate* (2018)

Difficult to reconcile CMIP5 models/forcing with strong extratropical precipitation increases observed since 1901. 1951-2010 is better

Zonal Averages of Precipitation Trends

1901-2010: CMIP5 model trends have a dry bias



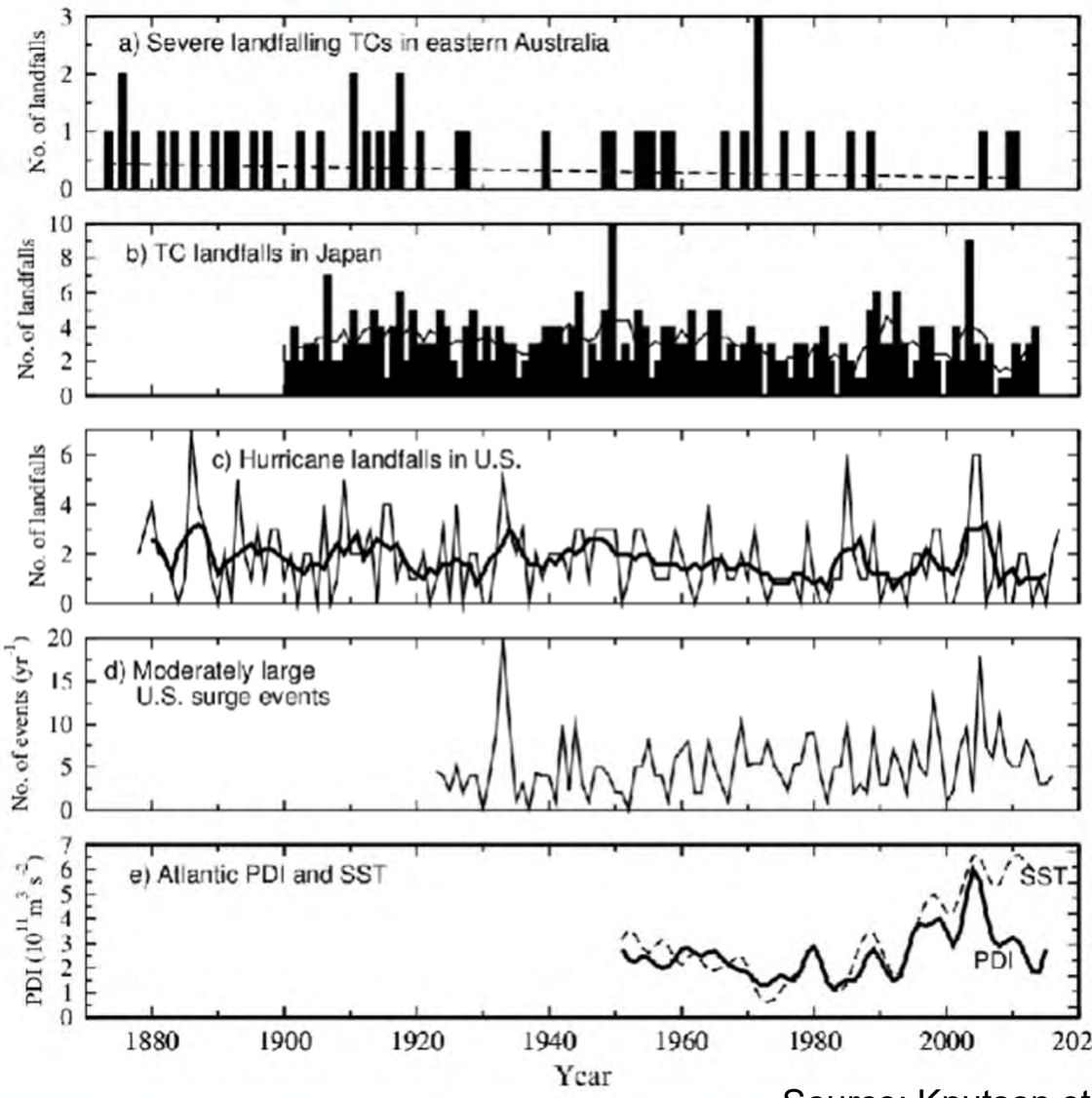
1951-2010: CMIP5 model trends are not as biased

1901-2010: Specifying SSTs in GFDL AM3 does not remove the dry trend biases.

1901-2010: Three observed datasets agree on extratropical trends

Source: Knutson and Zeng, *J. Climate* (2018)

GFDL leadership on a new WMO assessment of tropical cyclones and climate change:



Severe landfalling TCs in eastern Australia (Callaghan and Power)
** *Balance of evidence: Detectable decrease*

Landfalling TCs in Japan (Kumazawa et al. 2016)

U.S. Landfalling hurricanes (HURDAT)

U.S. Surge index for moderately large events (Grinsted et al)

Atlantic TC Power Dissipation Index and SST (Emanuel)

Source: Knutson et al., BAMS, early online release

Tropical Cyclones and Climate Change: Detection /attribution assessment

1) **Type I error avoidance** (i.e., avoid *overstating* anthropogenic influence or detection; Lloyd & Oreskes 2016):
   - Observed poleward migration of the latitude of maximum intensity in the western North Pacific is detectable, or highly unusual compared to expected natural variability *(low-to-medium confidence;* 8/11 authors*).*
   - *Low confidence* that any other observed TC changes represent either detectable or attributable anthropogenic changes (majority of authors).

2) **Type II error avoidance** (i.e., avoid *understating* anthropogenic influence or detection):
   - A balance of evidence suggests an anthropogenic influence on the following detectable changes:
     - poleward migration of the latitude of maximum intensity in the western North Pacific
     - increased occurrence of extremely severe (post-monsoon season) Arabian Sea TCs
     - increase of global average intensity of the strongest TCs since early 1980s
     - increase in global proportion of TCs reaching Category 4 or 5 intensity in recent decades
     - increased frequency of Hurricane Harvey-like extreme precipitation events in the Texas region.
   - A balance of evidence suggests an anthropogenic influence (without detection) on:
     - unusually high TC frequency near Hawaii in 2014
     - unusually active TC season in the western North Pacific in 2015.
   - A balance of evidence suggests detectable (but not attributable) changes:
     - decreases in frequency of severe landfalling TCs in eastern Australia since the late 1800s
     - decreased global TC translation speeds since 1949.

Source: Knutson et al., *BAMS*, early online release

Tropical Cyclones and Climate Change: Detection /attribution assessment

1) **Type I error avoidance** (i.e., avoid *overstating* anthropogenic influence or detection; Lloyd & Oreskes 2016):

- Type I error focus: Avoid overstating human influence
- Target audience: State of scientific knowledge
- One case: Latitude of max. intensity - NW Pacific (low-to-medium confidence)

2)

- A balance of evidence suggests an anthropogenic influence on the following detectable changes:
  - poleward migration of the latitude of maximum intensity in the western North Pacific;
  - increased occurrence of extremely severe (post-monsoon season) Arabian Sea TCs;

- Type II error focus: Avoid understating human influence
- Target audience: Risk assessment
- Nine published cases

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     - unusually high TC frequency near Hawaii in 2014 **[Murakami et al. 2015]**
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   (GFDL studies)
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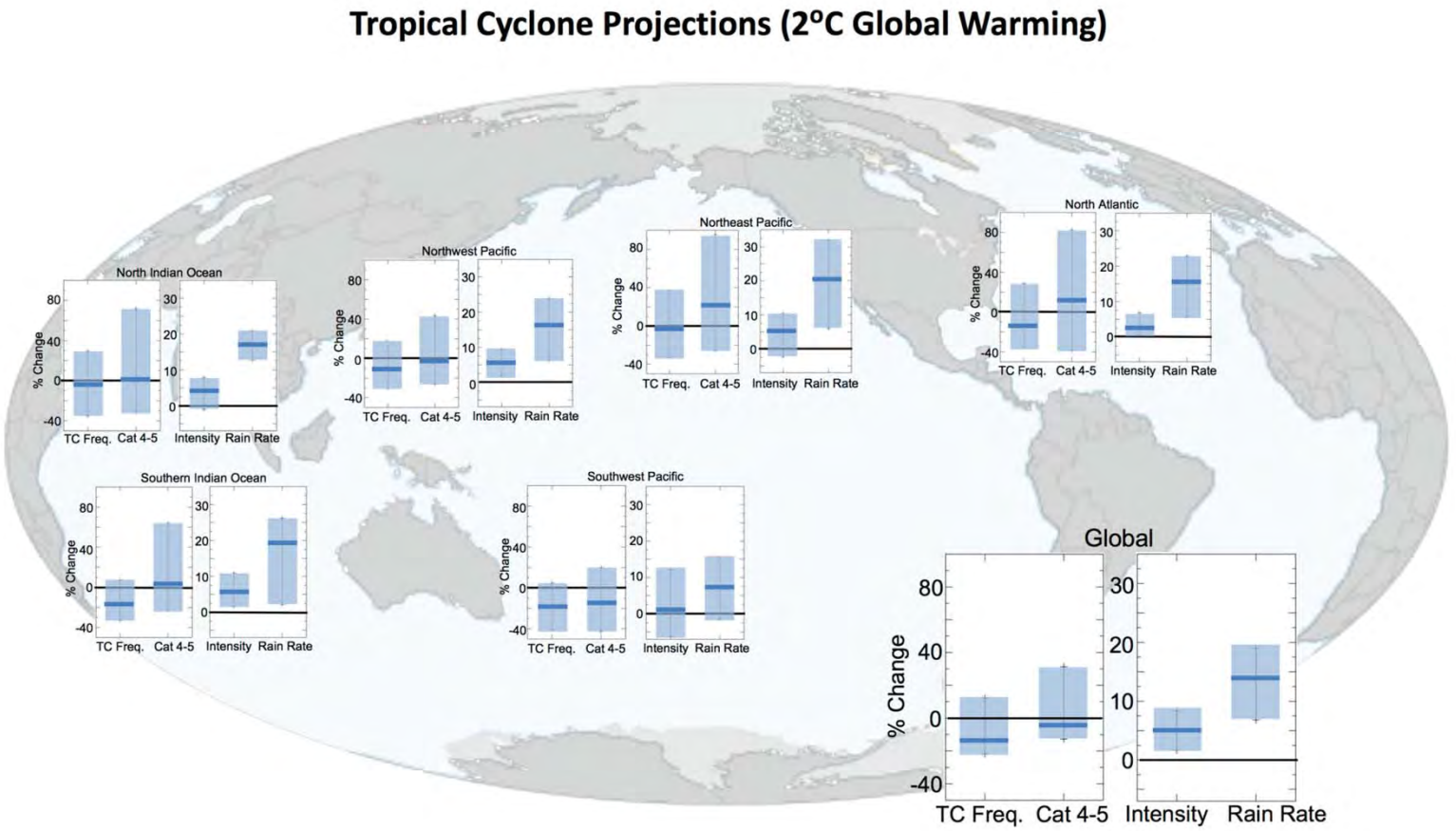
Tropical cyclone projections for 2°C global warming



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Future Plans & Challenges

Focus on using models and observations to explain notable past trends and variability in the climate system, with implications for current events and future projections.

Examples:

- Screening (falsifying?) model historical runs (model + forcing) for consistency with observations. Implications for plausibility of projections?
- Increase in Atlantic hurricanes since 1970s: internal variability vs. forced response to aerosols?
- Response of tropical Pacific/Walker Circulation to anthropogenic forcing: more El Nino-like or La Nina-like?
- Observed larger-than-simulated increase in precipitation over extratropical land regions since 1900?