Global Precipitation Characteristics

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Jim Steenburgh
Fulbright Visiting Professor of Natural Sciences
University of Innsbruck
Department of Atmospheric Sciences
University of Utah
jim.steenburgh@utah.edu

Annual Mean Precipitation

• Discussion
  – What are the primary features of the annual mean global precipitation distribution?
  – Why do these features exist?

Key Features: Tropics and Subtropics

ITCZ = Intertropical Convergence Zone
MC = Maritime Continent
SDZ = Subtropical Dry Zone
SPCZ = South Pacific Convergence Zone
SACZ = South Atlantic Convergence Zone

UCAR (2018), See also Adler et al. (2017)

ITCZ/SDZ Mechanisms

Mean position of ITCZ in NH is likely a consequence of continental geometry/asymmetry and ocean-atmosphere interactions
ITCZ shifts toward differentially warming hemisphere

UCAR (2018)
Schneider et al. (2014)

ITCZ Seasonal Cycle

Strong influence of Asian Monsoon
More subtle migration

Schneider et al. (2014)

Walker Circulation

Large-scale circulation over the tropical Pacific Ocean featuring easterly surface winds, rising motion and convective storms over the western Pacific and maritime continent, westerly flow aloft, and subsidence over eastern Pacific.

Monsoons

Large-scale circulation change produced by asymmetric heating of land & water areas, leading to a seasonal wind reversal and modulation of precipitation, typically resulting in pronounced dry and wet seasons.

Where: Central Africa, SE Asia, N Australia, SW North America, Amazon

Tropical Precipitation Systems

Importance of MCS

Key Features: Midlatitudes

Examples of orographic effects (poorly resolved)

Midlatitude Precipitation Systems

Cyclone Contribution

*Moisture transport feature
Orographic Effects

- Discussion
  - What are the primary features of the annual mean precipitation in the Alpine region?
  - Why do these features exist?
  - How do you explain local and regional maxima and minima in precipitation?
  - Frei and Schär (1998)

- Strong precipitation—altitude relationship, but also important:
  - Regional moisture availability and transport
  - Storm track and frequency
  - 3-D terrain effects
  - Effects of western hook
  - Concavity near Lago Maggiore
  - Barrier width and upstream water-vapor depletion
  - Tirol vs. Gotthard Pass
  - Frei and Schär (1998)

Snowfall

- NH Fraction greatest over Labrador Sea, South Greenland, Greenland Sea, Barents Sea, Sea of Okhotsk, Bearing Sea, Central Asia, Coastal Alaska/British Columbia
- Poleward shift over eastern Pacific and Atlantic, the latter producing lower fractions over western Europe
- NH Snowfall similar, except high altitude South Greenland sees relatively low amounts
- Many topographic effects poorly resolved

Mountain Solid Precipitation Water Equivalent

- SH Fraction and amount greatest along storm track
- Note lower values east of Antarctic Peninsula

Data Source: ZAMG, http://www.zamg.ac.at/histalp/dataset/grid/five_min.php
Mountain Solid Precipitation
Water Equivalent
Function of precipitation amount and snowfall fraction

Data Source: ZAMG, http://www.zamg.ac.at/histalp/dataset/grid/five_min.php

Snowfall Amount
Function of water equivalent and snow-to-liquid ratio (SLR)

Questions for Discussion

• What is the snowiest regular observing site in the world (snowfall amount)?
• What is the snowiest regular observing site in the Alps?
• What is the snowiest ski area in the world?
• What is the snowiest ski area in the Alps?
• Where are the deepest seasonal snowpacks in the world?

Note: The WMO does not recognize world snowfall measurements due to measurement issues

ENSO

El Niño/Southern Oscillation (ENSO) – Coupled ocean-atmosphere phenomenon involving variations in wind, SST, clouds, and precipitation in the tropical and subtropical Pacific Ocean with global impacts

Variability

Australian Government Bureau of Meteorology (2019)
**ENSO Global Impacts**

Positive Phase
- Strong polar vortex
- Cold arctic
- More zonal mid-latitude flow
- Weaker mid-latitude variability

Negative Phase
- Weak polar vortex
- Warm arctic
- Higher amplitude mid-latitude flow
- Mid-latitude cold surges

**AO**

Arctic Oscillation (AO) – Large-scale mode of climate variability involving variations in the strength of the circumpolar flow

Positive Phase
- Strong polar vortex
- Cold arctic
- More zonal mid-latitude flow
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Negative Phase
- Weak polar vortex
- Warm arctic
- Higher amplitude mid-latitude flow
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**NAO**

North Atlantic Oscillation (NAO) – Large-scale mode of climate variability involving variations in the strength of the North Atlantic subpolar high and subpolar low

Positive Phase
- Strong North Atlantic subpolar low
- Strong North Atlantic subpolar high
- North Europe Warm and Wet
- South Europe Dry

Negative Phase
- Weak North Atlantic subpolar low
- Weak North Atlantic subpolar high
- North Europe Cold and Dry
- South Europe Wet

**PDO and PNA**

Pacific Decadal Oscillation (PDO) – “ENSO-like”, long-lived mode of North Pacific sea surface temperature variability with impacts on mid-latitude circulations and weather that reflects several phenomena, including ENSO

Warm Phase
- Pacific-North America Index (PNA) – Large-scale mode of climate variability across the North Pacific and North America involving a "quadrupole" of 500 mb height anomalies

Cool Phase

**MJO**

MJO = Madden and Julian Oscillation
- Named for Drs. Roland Madden and Paul Julian who identified the phenomenon (Madden and Julian 1971)
- Eastward-moving disturbance that modulates tropical clouds and precipitation on seasonal to sub-seasonal time scales
- Impacts on extratropics too

**Words of Caution**

- Multiple physical processes, sometimes involving coupling between Earth system components (e.g., ocean and atmosphere) influence ENSO, AO, NAO, PDO, PNA, etc.
- ENSO, AO, NAO, PDO, PNA, MJO are not independent “actors”
- Indices used to define these phenomena vary
- Lots of use and misuse in research and forecasting
References
