The North American Monsoon and Flash Floods

Jason Knievel

Material contributed by: Nolan Doesken, Chuck Doswell, Dave Gochis, and Walt Petersen
What is a monsoon?

- A monsoon is a seasonal wind
- Associated with this seasonal wind are seasonal (and sometimes more local) changes in
  - Humidity
  - Cloud cover
  - Rainfall
  - Stream flows
  - Flooding
Cause of monsoons

- Changes in horizontal thermal gradients translate to changes in horizontal pressure gradients

- What drives thermal gradients? Oceans change temperature less than land in response to changes in sunshine
  - Ocean: higher heat capacity, more mass
  - Land: lower heat capacity, less mass
Cause of monsoons

What drives sea- and land breezes...

...also drives wet and dry monsoons

From Michael Pidwirny
Cause of monsoons
Classic Indian monsoon

From NCDC
Extent of NA monsoon

10-m wind and monsoon index (JJA precip / annual precip) from QuikSCAT

From Bordoni et al. (2004)
Effects of NA Monsoon

May

July

Mexico

From Dave Gochis
Effects of NA monsoon

From Dave Gochis
Effects of NA Monsoon

Peak river discharges by month at USGS stations

From Michaud et al. (2001)
Typical circulation pattern of NA monsoon

NCEP/NCAR Reanalysis (’79–’95) 500 mb Height, Streamlines

Apr–May

Jul–Aug

From Dave Gochis
Typical moisture pattern of NA Monsoon

NA Regional Reanalysis (’79-’04) Precipitable Water (mm)

From Dave Gochis
Moisture sources of NA monsoon

From Dave Gochis
Moisture sources of NA monsoon

Elements of the North American Monsoon over Northern Mexico

From W. Higgins
NA monsoon and flash flooding

Meteorological effects

From solarhaven.org

Hydrological effects

From Norm Illsley

Flash flood

From Norm Illsley
Meteorological ingredients of a flash flood

A statement of the obvious:

“The heaviest precipitation occurs where the rainfall rate is highest for the longest time”

- C. F. Chappell

What is high? What is long?
It depends, but \[1 \text{ in h}^{-1}\] for \[1 \text{ hour}\] are good starting points
Meteorological ingredients of a flash flood

- High rainfall rate
  - Deep moist convection
  - High precipitation efficiency

- Long duration
  - Large storms
  - Slow storms

From UCAR
Meteorological ingredients of a flash flood

- Precipitation efficiency

From Doswell et al. (1996)

Efficiency = Output / Input

In this example: 44%

Input: water vapor

Output: precipitation

Water Mass (arbitrary units)

Time (arbitrary units)
Meteorological ingredients of a flash flood

- Precipitation efficiency

High humidity through a deep layer is important

Profiles of $T$ and $Td$ are tropical

DEN sounding before flood in Fort Collins, CO, July 1997

From Petersen et al. (1999)
Meteorological ingredients of a flash flood

- Large, organized storms

From Doswell et al. (1996)
Meteorological ingredients of a flash flood

- Slow storms

  - Mean advective wind
  - Cell motion
  - Propagation
  - Net storm motion
Difficulty of forecasting flash floods

- The most critical features of a flood-producing storm are often too small or subtle for models and in-situ observations to capture.

- Best approach: use synoptic and mesoscale forecasts as guidance for flooding potential, then rely on observations (especially remotely sensed) in the short term:
  - High humidity through deep layer
  - Slow steering wind (sometimes low shear, too)
  - Mechanism for counter propagation and organization of convection (boundary, terrain, etc.)
Surface obs and streamlines
Reflectivity ≥ 35 dBZ

1800 MDT

1900 MDT

2000 MDT

2100 MDT
Fort Collins, Colorado, 28 July 1997

Rainfall (inches)
1730-2300 MDT
28 July 1997
Fort Collins, Colorado, 28 July 1997
Additional reading


