watercongress2019

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State-of-the-Practice PMP and Meteorological Parameter Development for TSF Facilities, El Abra, Mine, Chile

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Probable Maximum Precipitation

- PMP Definition: The theoretically greatest depth of precipitation for a given duration that is physically possible over a given storm area at a particular geographic location at a certain time of year (HMR 59, 1999)
- World Meteorological Organization (WMO, 2009) identifies 5 different PMP estimation methods
- PMP developed using the storm-base method
  - Storm-based approach for durations ranging from 1-hour to 72-hour as defined in WMO (2009)
    - Hershfield and Stowhas for the 24-hour PMP

Probable Maximum Precipitation

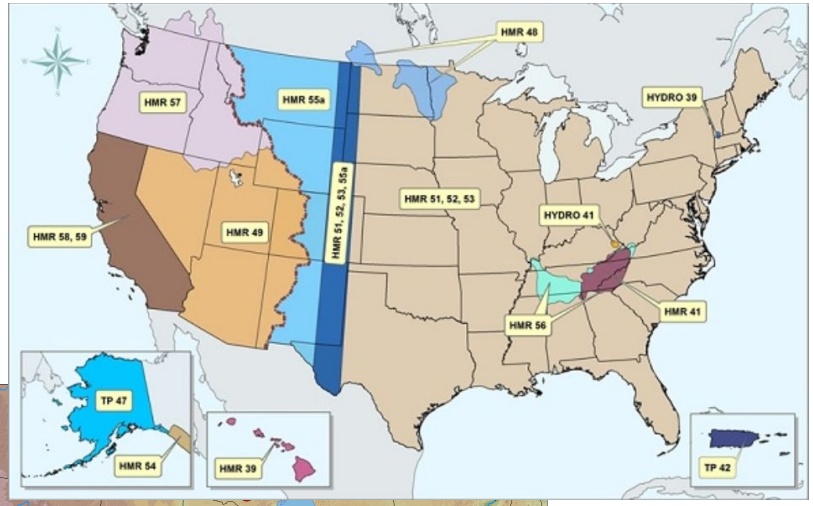
- Storm Based Approach-Deterministic
  - Maximize storms
  - Transposition storms
- Combine into PMP design storm
  - By storm type
  - By area size
  - By duration
- Expert judgment involved
- Probabilistic estimates now available as well

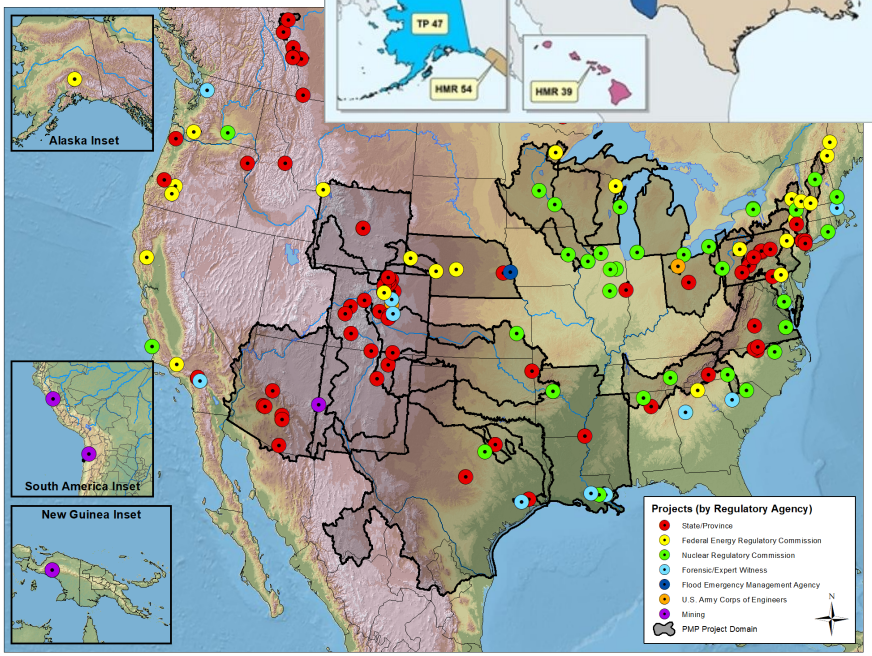
Storm Based vs Hershfield

- Hershfield method good for first approximation/initial design
  - Provides required estimate
  - Relatively quick to perform
  - Can be used when there is a lack of data
- Generally produces conservative values-requires several key assumptions
  - Which statistical fit to use?
  - How representative is the station of the overall basin?
- Hershfield does not explicitly derive data for different durations/area sizes (e.g., 24-hour storm only)
- Lack of accounting for orographics
- Lack of accounting for seasonality
- Site-specific storm characteristics and areal reduction not used

Storm-Based Method Worldwide

- WMO PMP Manual
  - Section 1.4.3.1.1
- US National Weather Service HMRs
- Most PMP studies in Europe and Asia
- Storm Based Approach is Data Dependent



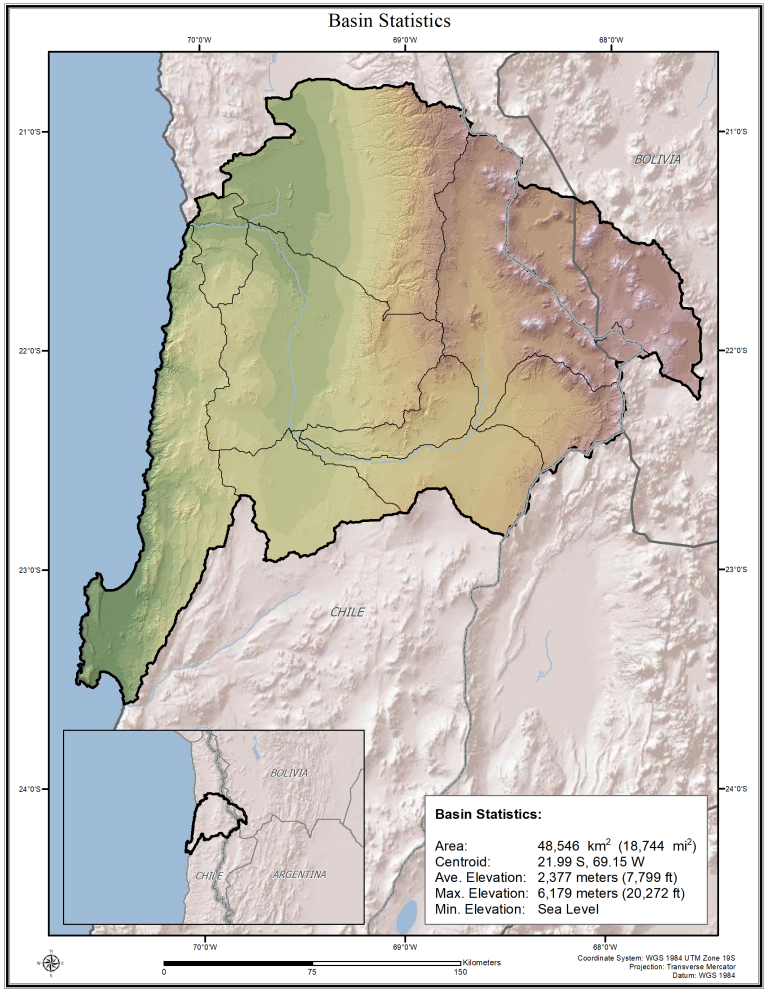


Probable Maximum Precipitation

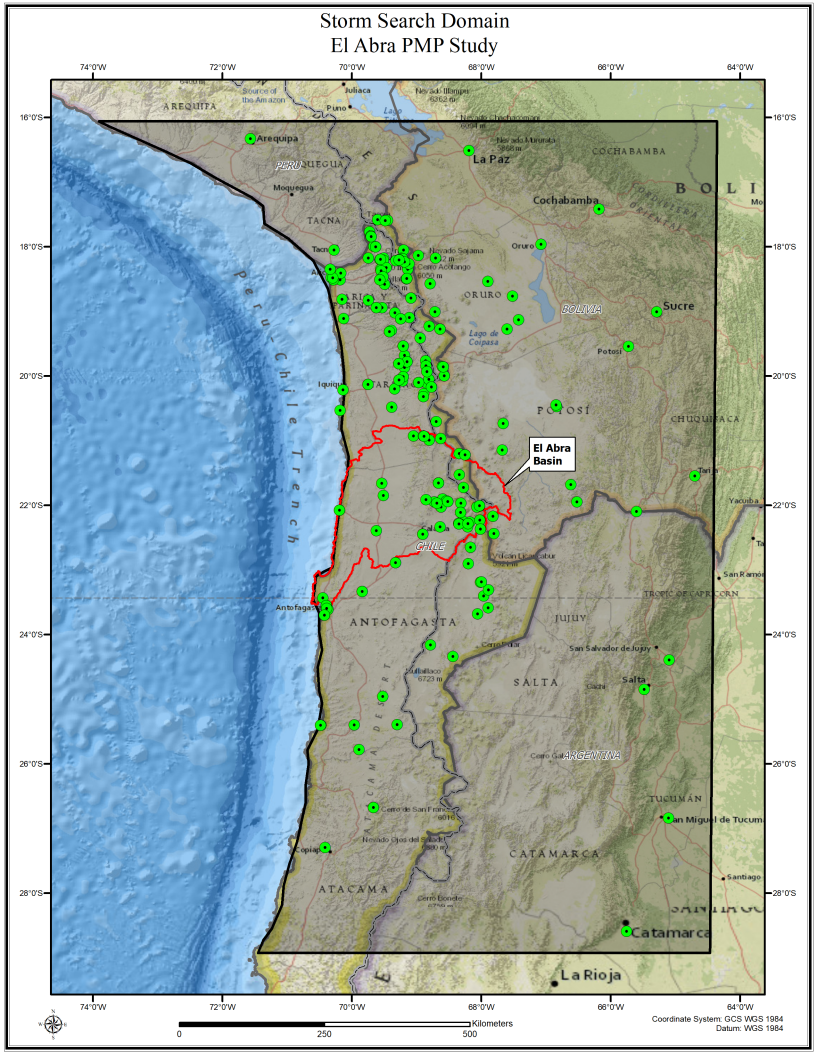
- Storm Search and Storm List
  - Complete a storm search to identify the most significant storms that could have occurred over the region where storms are transpositionable
  - Identify the most significant flood events that have occurred in region
  - Identify storms used in other PMP studies
  - Identify extreme rainfall-producing storm types and seasons
  - Use SPAS to analyze
- Storm must have similar meteorology/topography to be considered transpositionable

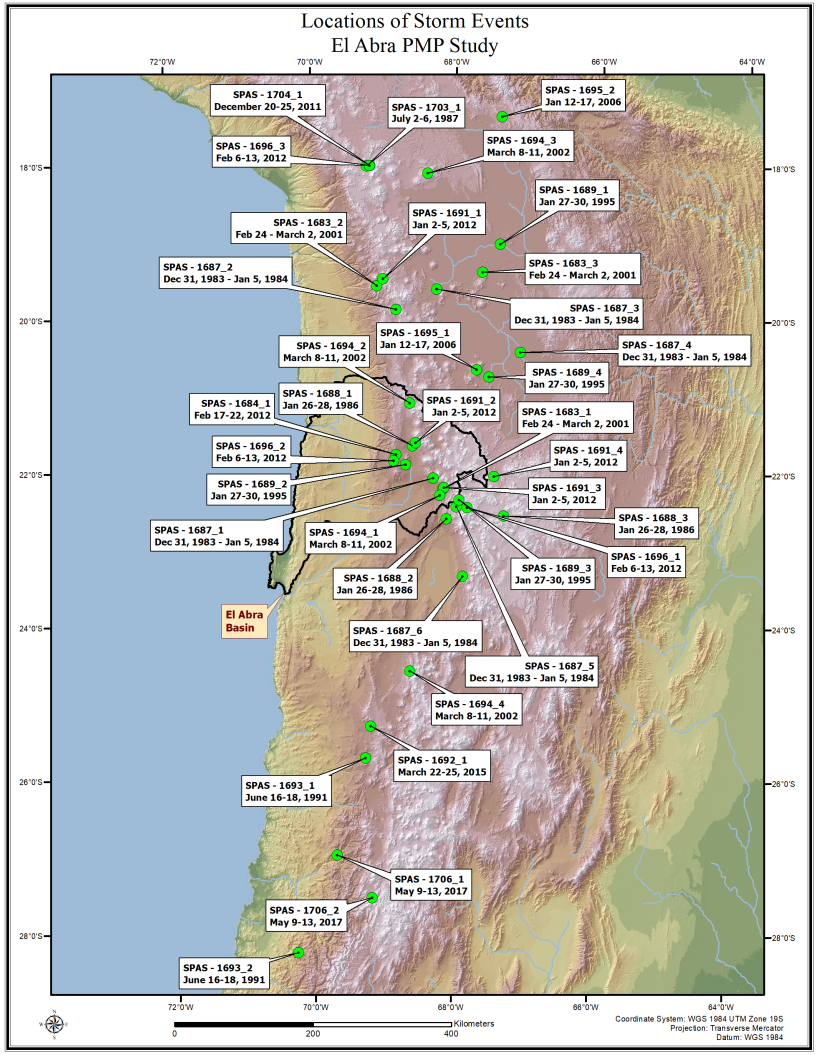
El Abra Meteorological Setting

- Andean Mountains to Pacific Ocean
- Unique Climate & Topography
- Hyper arid to Relatively Wet
- Distinct wet/dry seasons
- Limited data, especially sub daily
- Utilize remote sensing

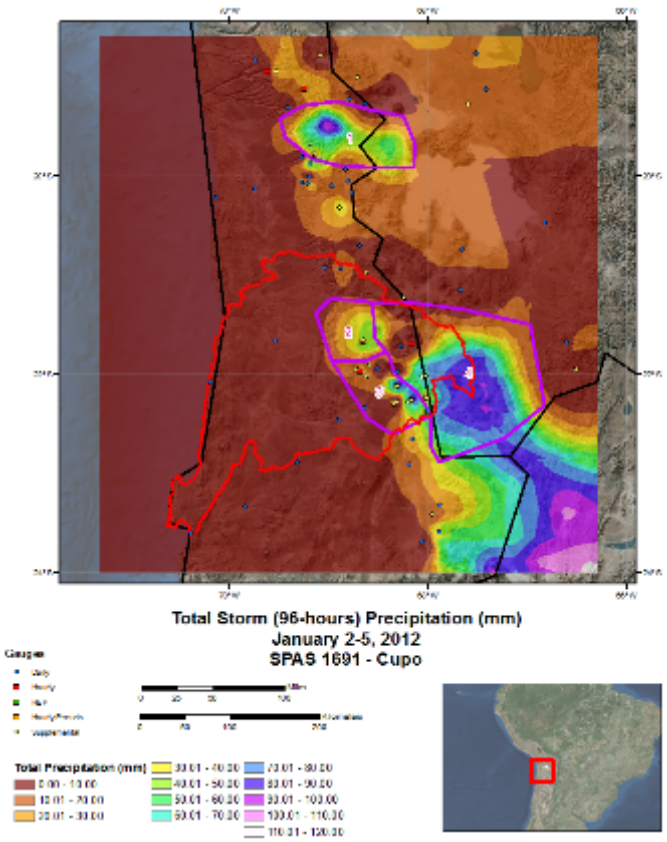


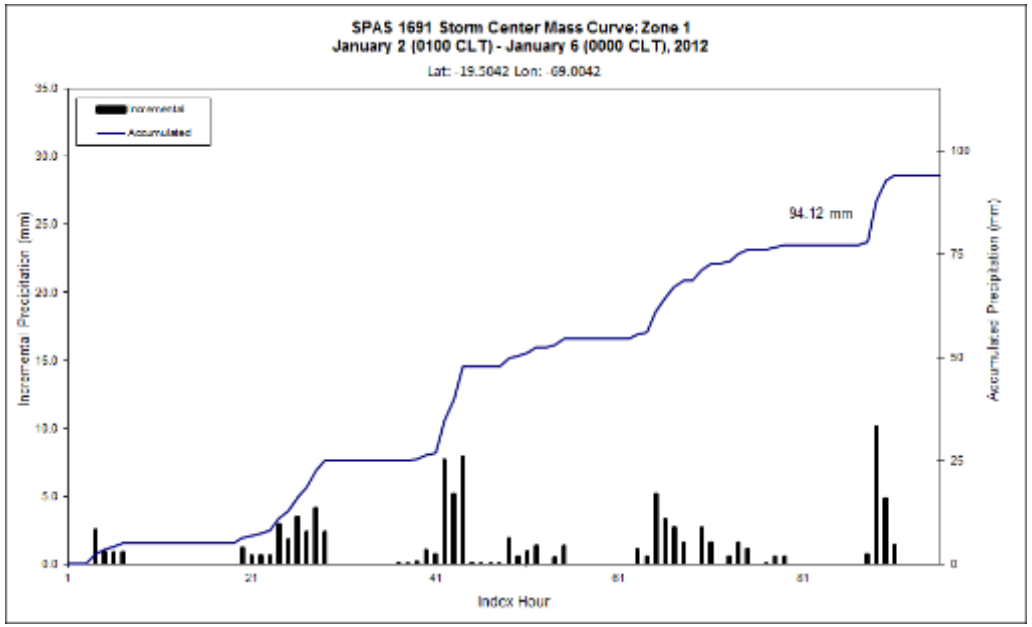
Storm Search and Storm Centers





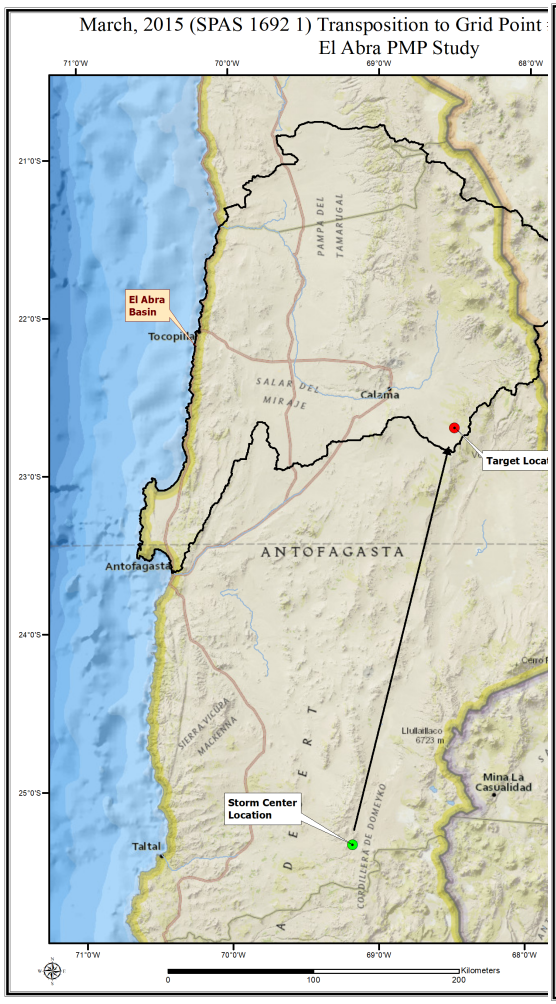
Storm Analysis Example Results

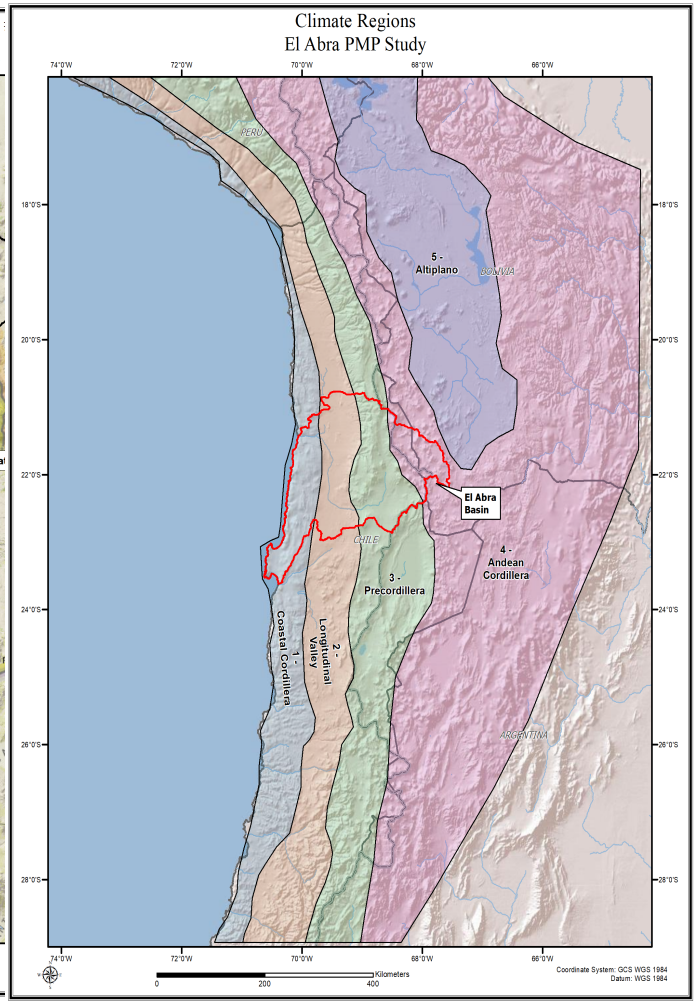




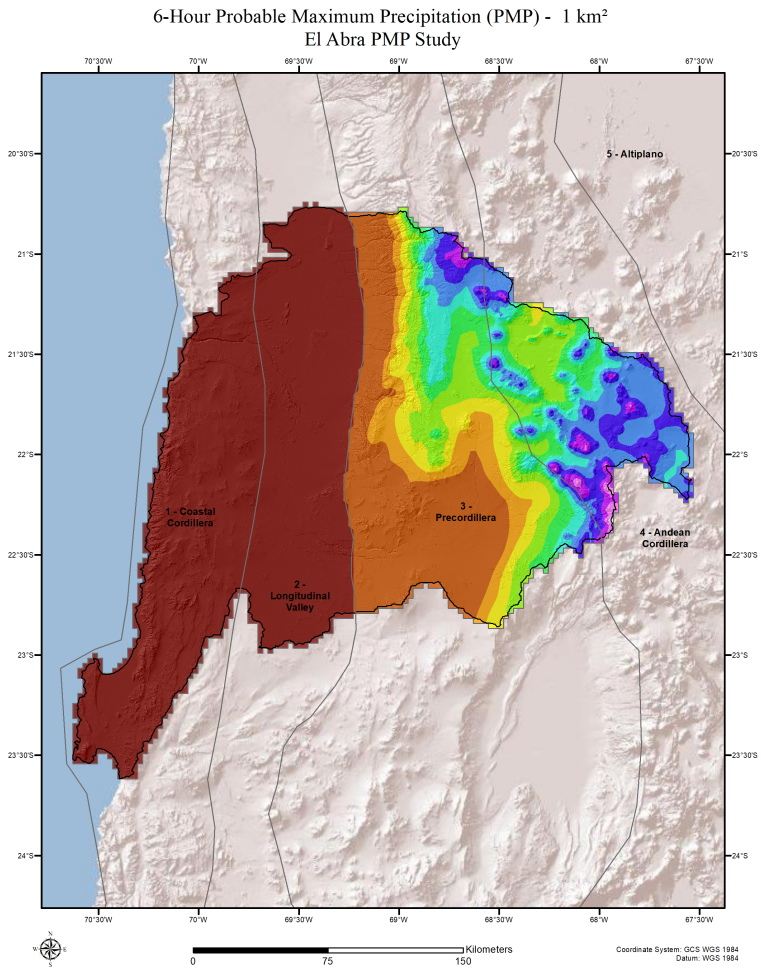
Maximization-Transposition

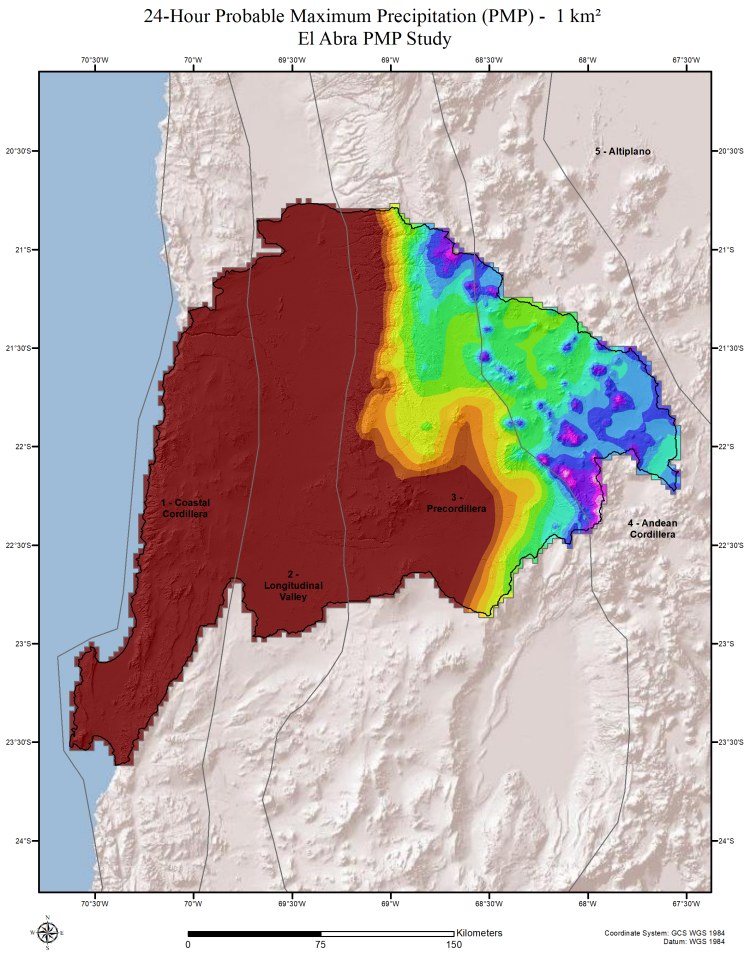
- Storms are maximized in place by adjusting available moisture to estimate how much bigger the storm could have been had all the conditions been "perfect"
- Transposition factors are then applied that adjust for topography and moisture differences within in a defined region where similar storms are likely to occur
  - Not all storms are transposable to all regions





Example PMP Results

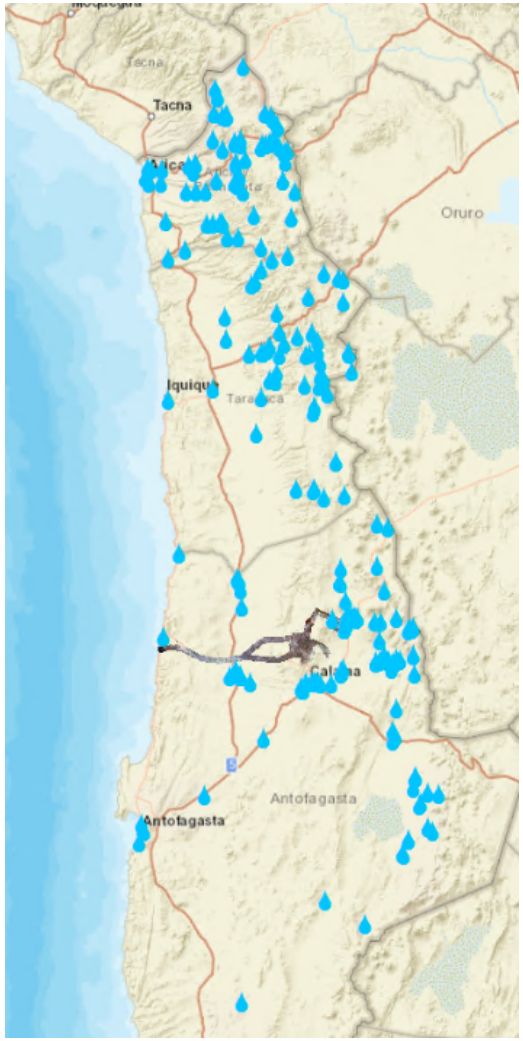




Regional Precipitation Frequency

- Frequency analysis is the estimation of how often a specified event will occur.
- Procedures for statistical frequency analysis of a single set (e.g., location) of data is well-established.
- It is often the case, however, that many related samples of data are available for analysis.
- If event frequencies are similar for the different observed quantities, then more accurate conclusions can be reached by analyzing all the data samples together than by only using a single example.

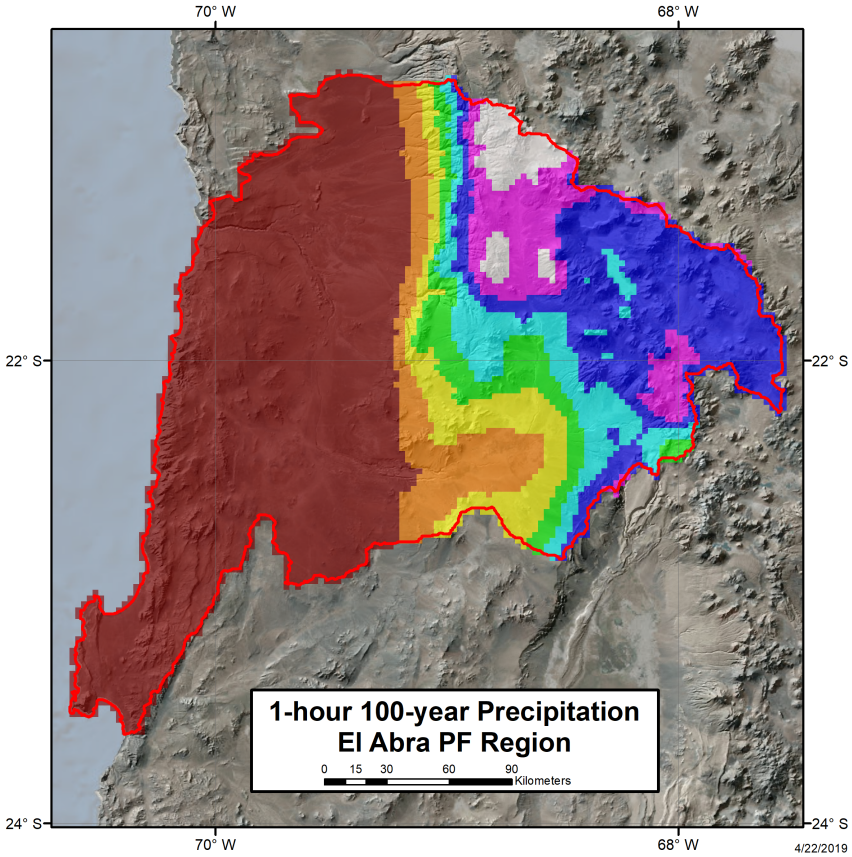
Hosking and Wallis, 1997. *Regional Frequency Analysis: An Approach Based on L-Moments*. Cambridge University Press, Cambridge, UK.

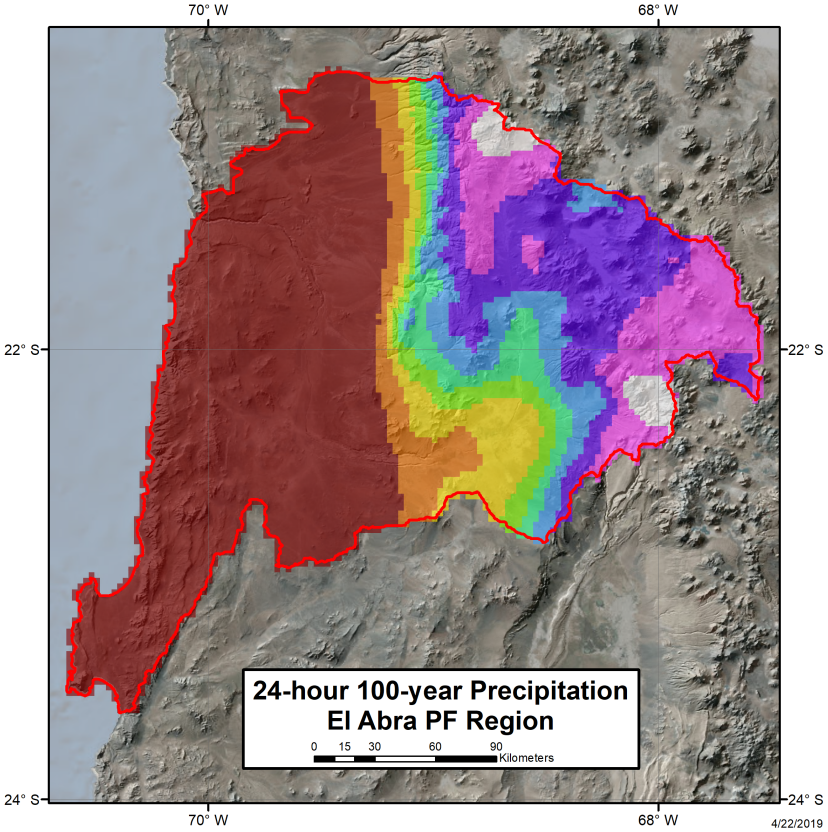


Precipitation Frequency Approach

- Develop a map of climatology over the period of record
  - Mean annual precipitation, elevation-precipitation relationship
- Derive at-a-station statistics (e.g., 100-year and mean annual maximum, or MAM)
- Normalize and then scale precipitation at each station
- Pool all normalized data (trade space for time)
- Develop a regional growth curve (statistical fit of pooled data)
- Use statistical relationships between the MAP, MAM, and elevation to derive a continuous surface of precipitation for a given duration and recurrence interval

Example Precip Frequency Results

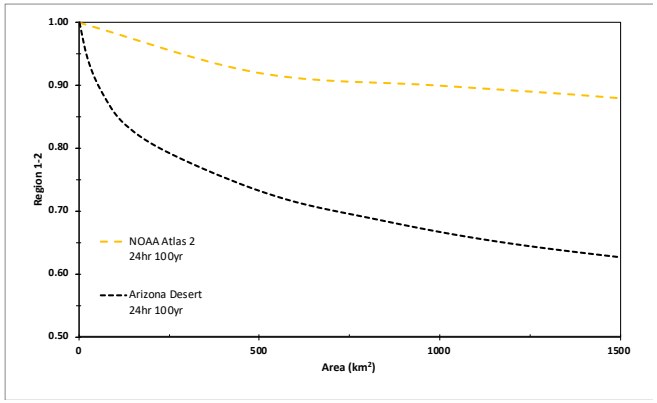


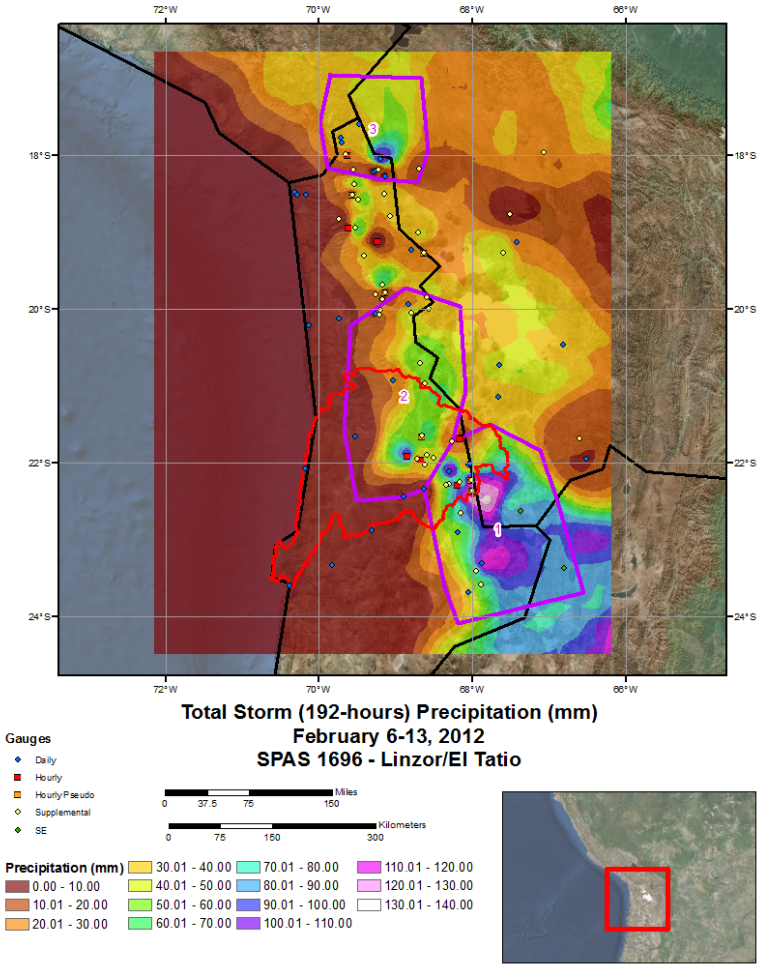


Similar products for durations 1, 6, 24, 72 hour, and ARIs 1, 2, 5, 10, 25, 50, 100, 200, 500)

Areal Reduction Factors

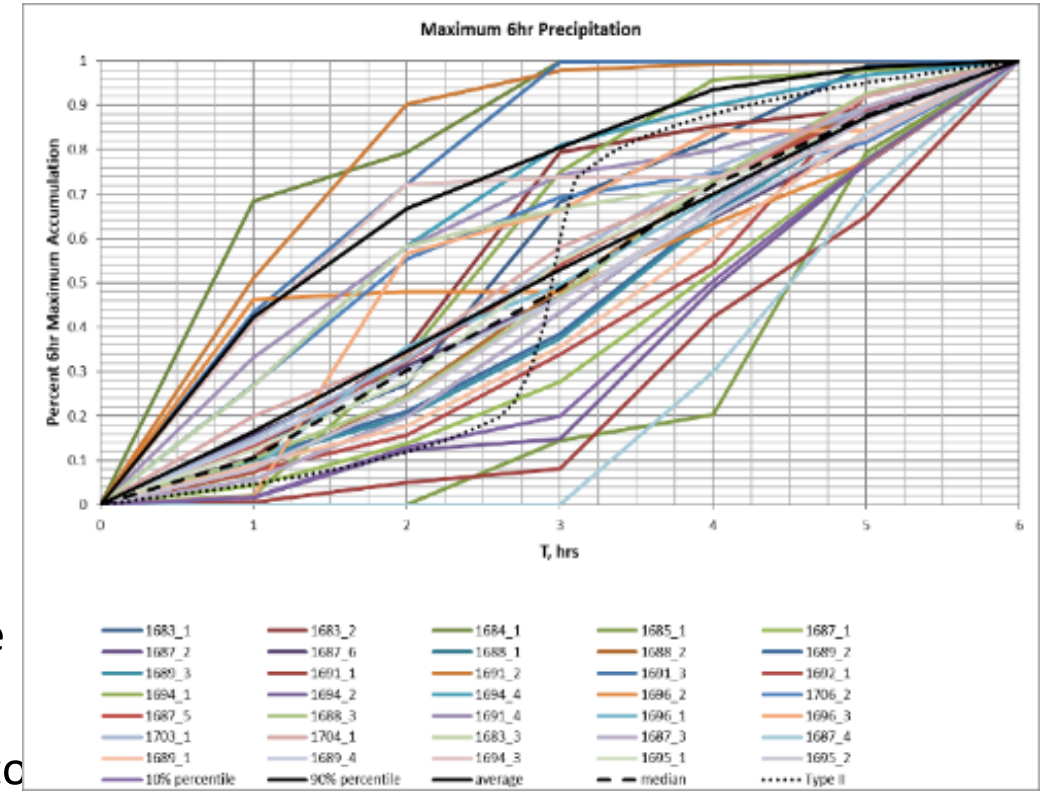
- NOAA defines ARF as the ratio between area-averaged rainfall to the maximum depth at the storm center
- AWA calculated ARFs using a storm centered depth-area approach based on gridded hourly rainfall data
- ARF results are different than previously used value
  - Larger areas (> 25km2) decay more rapidly
  - Smaller areas (< 25km2) more decay
  - ARFs for different climatological regions



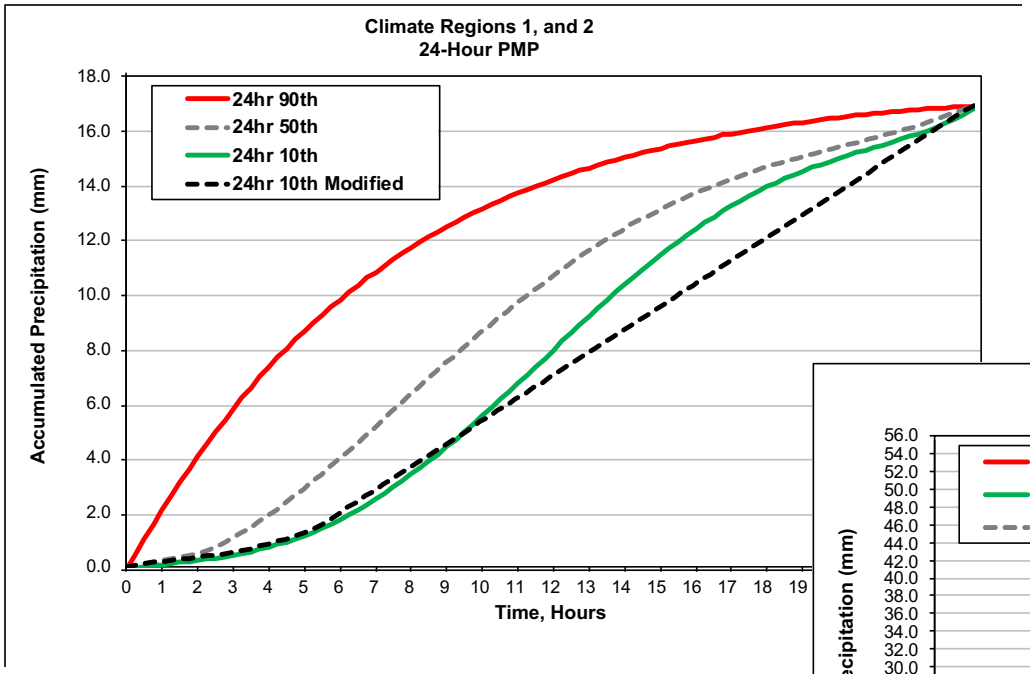


Temporal Accumulation Patterns

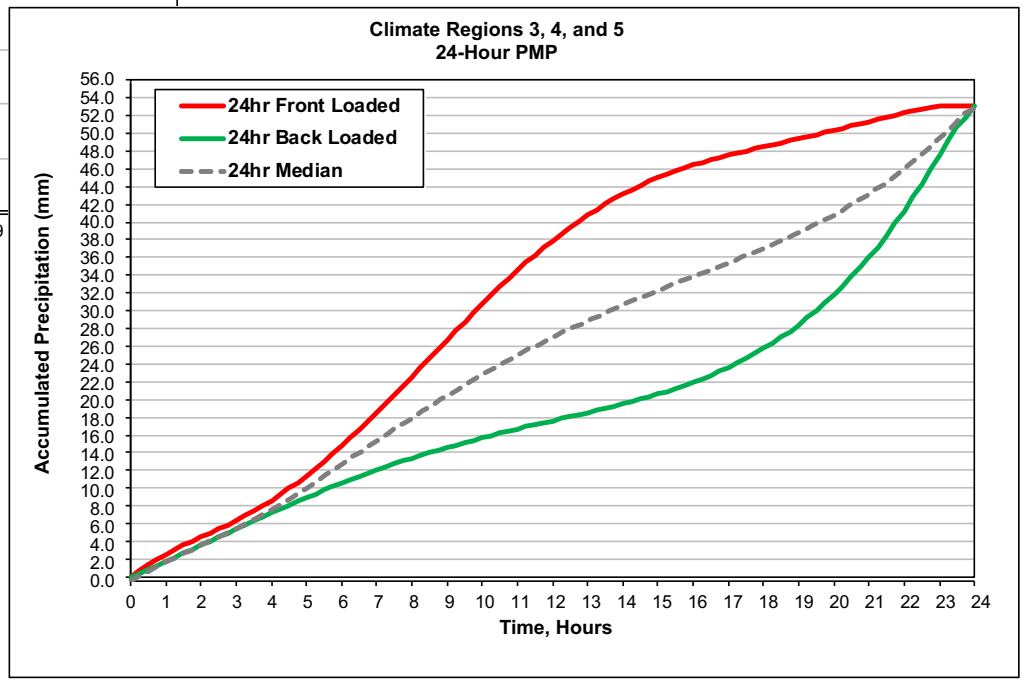
- Evaluated accumulation patterns from SPAS
- Data split into 2 regions
  - Coastal/Longitudinal Valley
  - Precordillera/Cordillera/Altiplano
- Applied statistical fits to develop various curve shapes
- 29 temporal patterns developed and added to PMP-Tool
- Performed several sensitivities/error checks to ensure PMP not exceeded
- Applied meteorological judgment to smooth curves and apply physically possible scenarios



Example Temporal Patterns

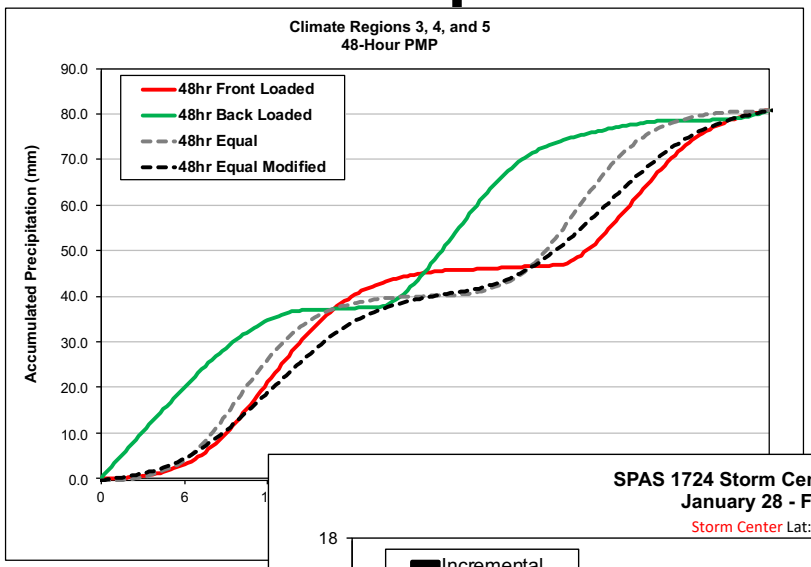


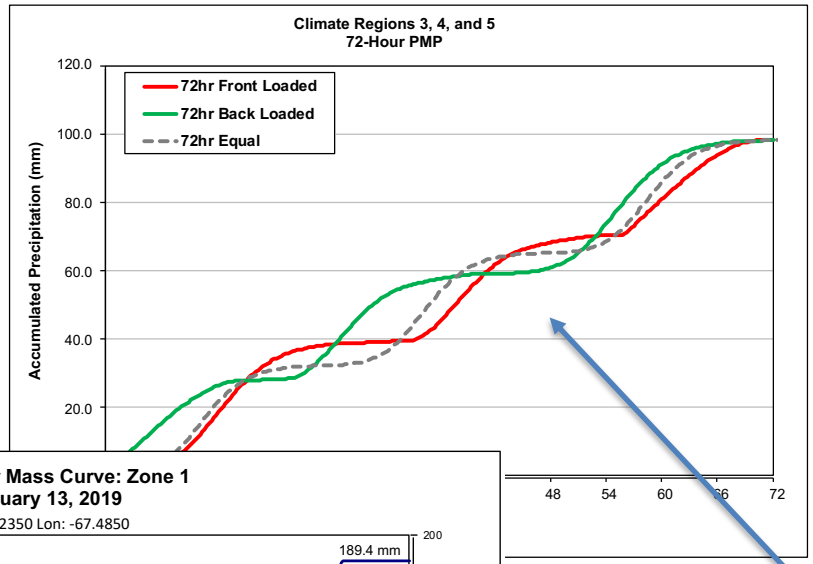
- **Coastal**
- **Longitudinal Valley**

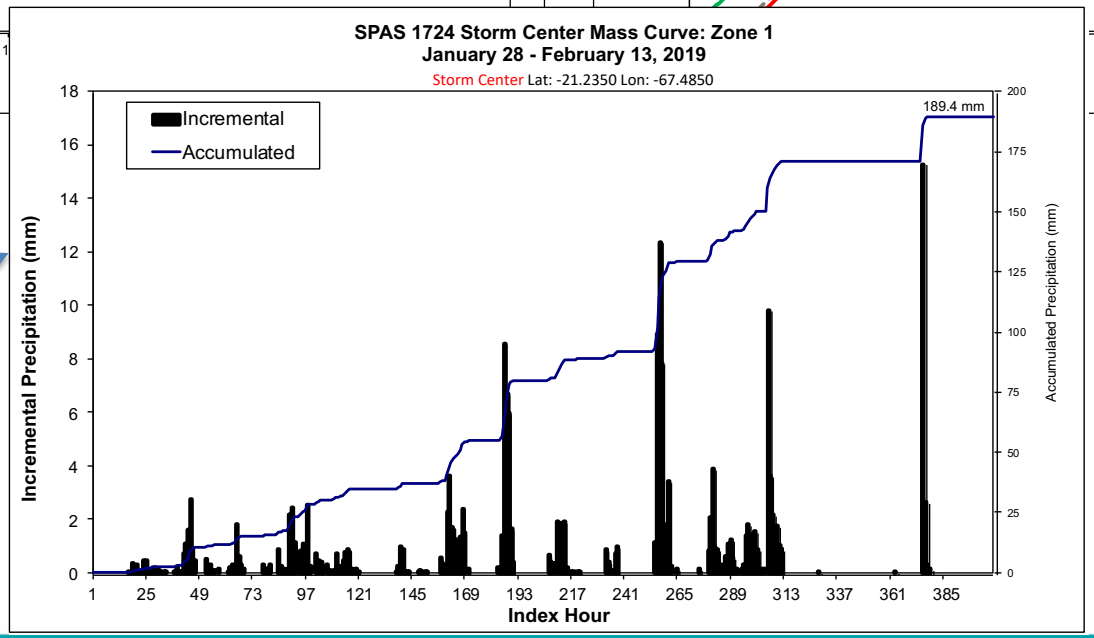


- **Pre-cordillera**
- **Andean Cordillera**

Example Temporal Patterns







Pre-cordillera

Andean Cordillera

Jan-Feb heavy rainfall in the region

Benefits to Engineering Hydrology

- Storm-based approach to extreme precipitation and PMP reduces the number of *assumptions* required in hydrological model and increases the amount of *data-based estimates*.
  - Precipitation depths over range of meteorologically and hydrologically relevant durations versus the somewhat arbitrary "24-hour storm"
  - Areal reduction factors to estimate decay of storm spatially
  - Duration-specific hyetographs, including the ability to create stacked hyetographs when appropriate
  - Based on latest events—can be updated in repeatable manner when new extreme events come up (e.g., Jan/Feb 2019 event)

Questions?

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