ESTIMATION OF LAND SURFACE PRECIPITATION FOR CONTIGUOUS U.S. USING A NEW SPATIAL INTERPOLATION METHOD

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• The important role of mountains in producing water supplies demands more accurately estimates of land surface precipitation fields

• Differences among available land surface precipitation datasets: uncertainty in land surface precipitation variability and change (Nickl et al., 2010)

• Mountainous regions: substantial differences among datasets, especially over the Andes, the Alps and the Himalayas

• Development of a new spatial interpolator that takes into account important topographic features evaluated at different spatial scales
GOALS

• To assess the performance of the new spatial interpolation method to estimate land surface precipitation over contiguous U.S. (2.5-minute resolution)

• To compare precipitation estimates with estimations from Cressman’s traditional interpolator, the National Centers for Environmental Information (NCEI/NOAA) and the Parameter-elevation Regressions on Independent Slope Model (PRISM)

DATA AND METHODS

• Monthly gridded estimates of precipitation (1895-2013) from NCEI/NOAA and PRISM to estimate spatially weighted (geographic) percentiles
• Precipitation climatologies (1981-2010) from the Global Historical Climatology Network (GHCN)
• U.S. Digital Elevation (DEM) information at 2.5 minutes resolution to estimate topographic features at different spatial scales
INTERPOLATION METHODS APPROACHES

• Cressman Traditional Interpolation: Inverse Distance Weighting

• PRISM
  o Regression function (distance, elevation, cluster, vertical layer, topographic facet, coastal proximity, topographic position and effective terrain)
  o Topographic facet: contiguous terrain slope with a common orientation
  o 5-minute DEM resolution: orographic scale
  o Use of diverse ranges and default parameters

• NCEI
  o Climatologically Aided Interpolation (CAI)
  o Climate normals grids are produced using the thin-plate smoothing spline method, using a smooth function of latitude, longitude and elevation
Spatial mean, 25th, 75th and 95th spatial percentile of U.S. annual precipitation (1895-2013): NCDC and PRISM (grids with elevation greater than 500m)
A NEW METHOD OF SPATIAL INTERPOLATION

\[ \hat{P}'_j = \hat{P}_j + \Delta P_j \]

\( \hat{P}_j \) Estimated precipitation using traditional interpolation (Cressman)

\( \Delta P_j \) Estimated bias when topography was not taken into account

\( \hat{P}'_j \) New estimate

\( \Delta P_j \) Estimation (when topography is not taken into account)

1. Cross-validation to obtain \( \Delta P_i \) at each station

2. Correlations between \( \Delta P_i \) and topographic patterns for different orographic scales:
   - Elevation (\( \bar{Z}_i \))
   - slope orientation (\( \frac{dz}{dx} \) and \( \frac{dz}{dy} \))
   - Exposure to orography (\( E_i^p \))

These correlations are performed within an “orographic region.”
OROGRAPHIC SCALE

- Represents that resolution of topography at which the topographic relationship with precipitation is “optimal”
- Averaging up from a high-resolution DEM to a more coarse spatial resolution

Identification of the “orographic scale” at which maximum correlations take place

3. Multiple linear regressions (MLR) using the optimum “orographic scale” for each region
   Dependents variable: $\Delta P_i$
   Independent variables: $\bar{z}_i$, $\frac{dz}{dx}$, $\frac{dz}{dy}$, $E_i^P$
   Regression parameters ($\beta_0, \beta_1, \beta_2, \beta_3, \beta_4$) for each “orographic region”

4. Estimation of: $\Delta P_j = \beta_0 + \beta_1 \times \bar{z}_j + \beta_2 \times \frac{dz}{dx} + \beta_3 \times \frac{dz}{dy} + \beta_4 \times E_j^P$
PRECIPITATION ERRORS FOR SEASONAL CLIMATOLOGIES

JFM

AMJ

JAS

OND
RELATIONSHIPS BETWEEN PRECIPITATION ERRORS AND TOPOGRAPHIC VARIABILITY

ELEVATION

DZ/DX

correlation
- < -0.75
- -0.75 to -0.5
- -0.5 to -0.25
- -0.25 to 0
- 0 to 0.25
- 0.25 to 0.5
- 0.5 to 0.75
- > 0.75

DZ/DY

EXPOSURE
RELATIONSHIPS BETWEEN PRECIPITATION ERRORS AND TOPOGRAPHIC VARIABLES

1. ELEVATION
   - higher: underestimates
   - lower: overestimates

2. DZ/ DX
   - west: underestimates
   - east: overestimates

3. DY/ DX
   - south: underestimates
   - north: Relationship not clear

4. TREND SURFACE
   - underestimates
   - overestimates
\[ \hat{P}_j' = \hat{P}_j + \Delta P_j \]
Precipitation estimates for JFM (1981-2010)

**New interpolator**

**NCEI/NOAA**

**PRISM**
Precipitation estimates for JAS (1981-2010)

New interpolator

PRISM

NCEI/NOAA
Evaluation of estimates of precipitation JFM (stations with elevations greater than 500m)

Traditional (Cressman)

New spatial interpolator
Evaluation of estimates of precipitation JAS (stations with elevations greater than 500m)

Traditional (Cressman)

New spatial interpolator

NCEI/NOAA
EVALUATION OF ESTIMATES OF PRECIPITATION

All stations contiguous U.S

At stations with elevation greater than 500m
CONCLUSIONS

• Some differences in precipitation estimates between NCEI/NOAA and PRISM are found, especially in higher spatial percentiles.

• Relationships between precipitation errors and topographic patterns are optimized when taking into account different orographic scales.

• Errors obtained from cross-validation show lower values for the new spatial interpolator compared to traditional interpolation. Errors from NCEI/NOAA show lower values especially for JFM (a different method is applied to estimate errors for NCEI/NOAA)

• West region shows larger error values for JFM. East region exhibits lower and similar error values for JFM and JAS.

• The new spatial interpolator represents an important contribution to precipitation interpolation and estimation, since it can be applied to any region of the world and does not require a number of area-specific parameters.