Chemical weathering and physical erosion rates along a vegetation and climate gradient, Chilean Coastal Cordillera (26° – 38°S)

Nahuelbuta, Chile

Mirjam Schaller and Todd A. Ehlers

Department of Geosciences
Earth System Dynamics Research Group
University of Tübingen, Germany

Study objectives

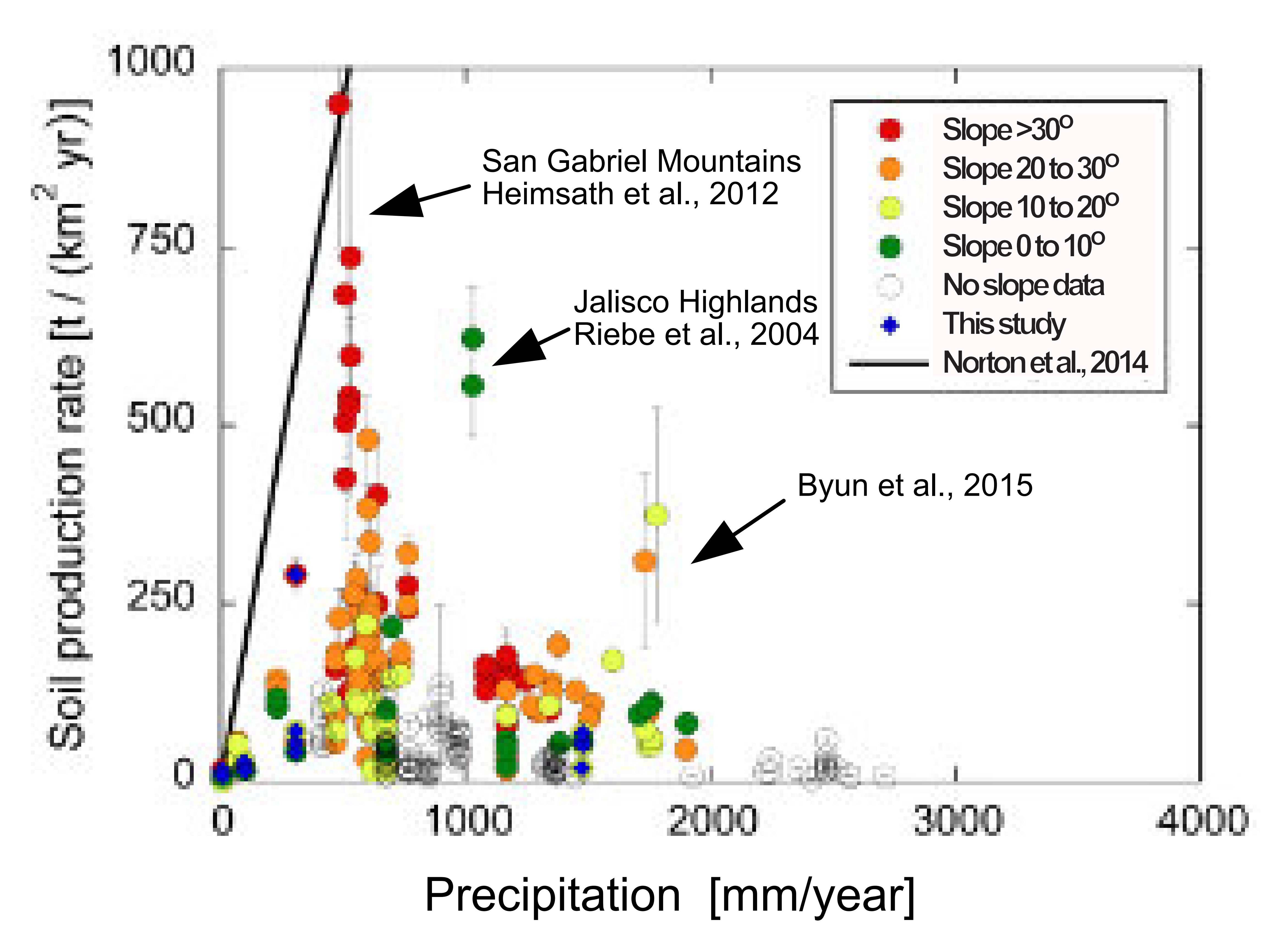
Problem addressed:

What governs soil production, chemical weathering, and physical erosion rates:

1. Geology?
2. Climate?
3. Vegetation?

- **Methods: Cosmogenic nuclides (11 new data and Schaller et al., 2018), immobile and mobile elements (Oeser et al., 2018)**
- **Rates from a climate and vegetation gradient in the Chilean Coastal Cordillera in EarthShape (www.earthshape.net) study areas.**
  (Precipitation rates from N to S: 13, 64, 394, and 1435 mm/year)
  (Vegetation cover from N to S: 2, 31, 84, and 95%)
- **Comparison to rates in granitic settings world-wide (~300 sample locations)**

Soil production rate vs. precipitation



Soil production rate:

- $E_{sap} = W_{soil} + E_{soil}$

World-wide:

- Highest rates with steepest slopes
- Increase in soil production rates up to ~700 mm/a, then decrease in soil production rates
- Increase in maximum soil production rates on bare rock with increasing precipitation (Norton et al., 2014)

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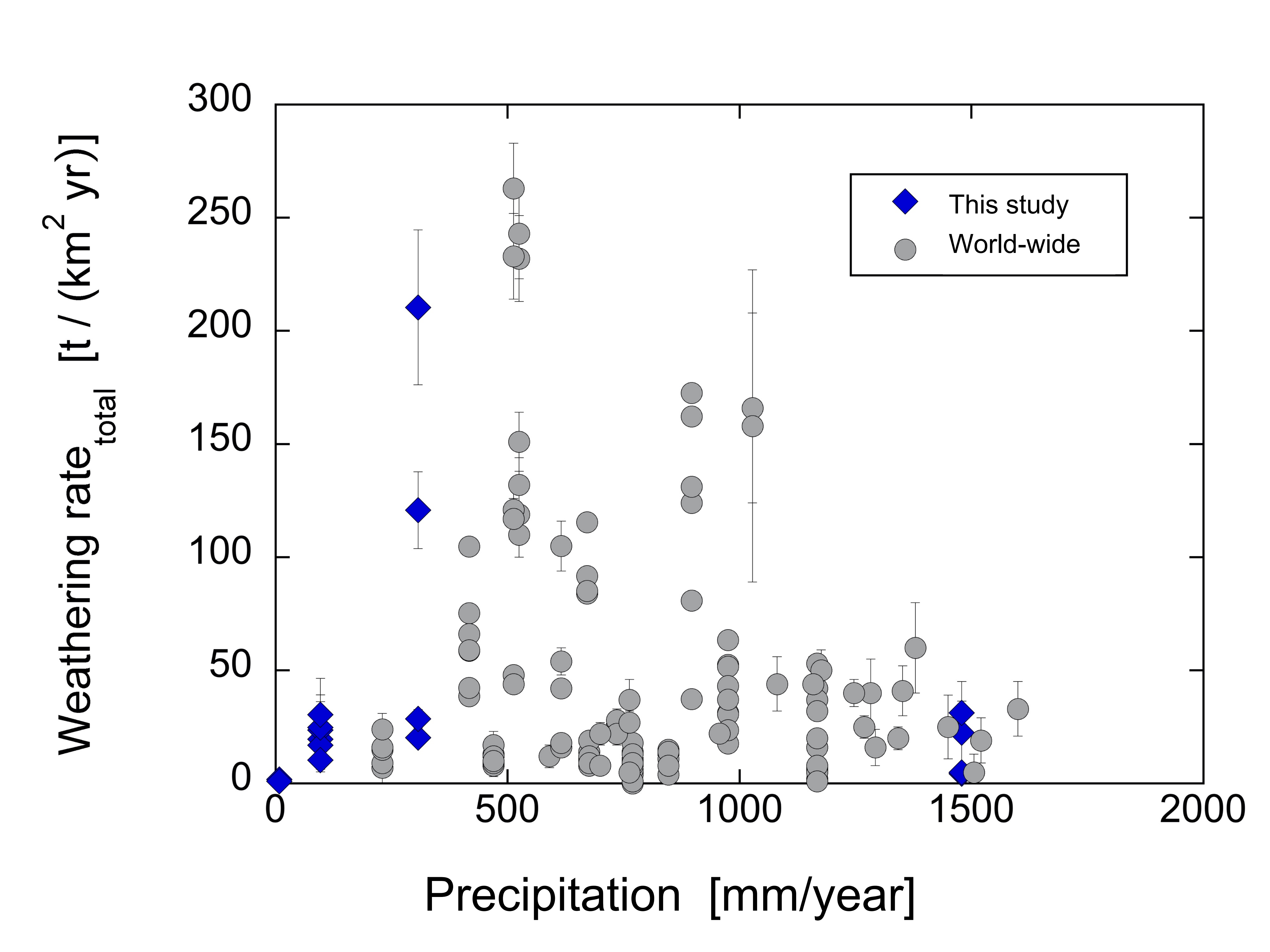
Take home message: Decrease in soil production rates at high precipitation rates.

Weathering rate vs. precipitation



Weathering rate:

- $W_{total} = W_{soil} + W_{sap}$

World-wide:

- Increase in weathering rates to precipitation rates of ~500 mm/year, then a decrease in weathering rates

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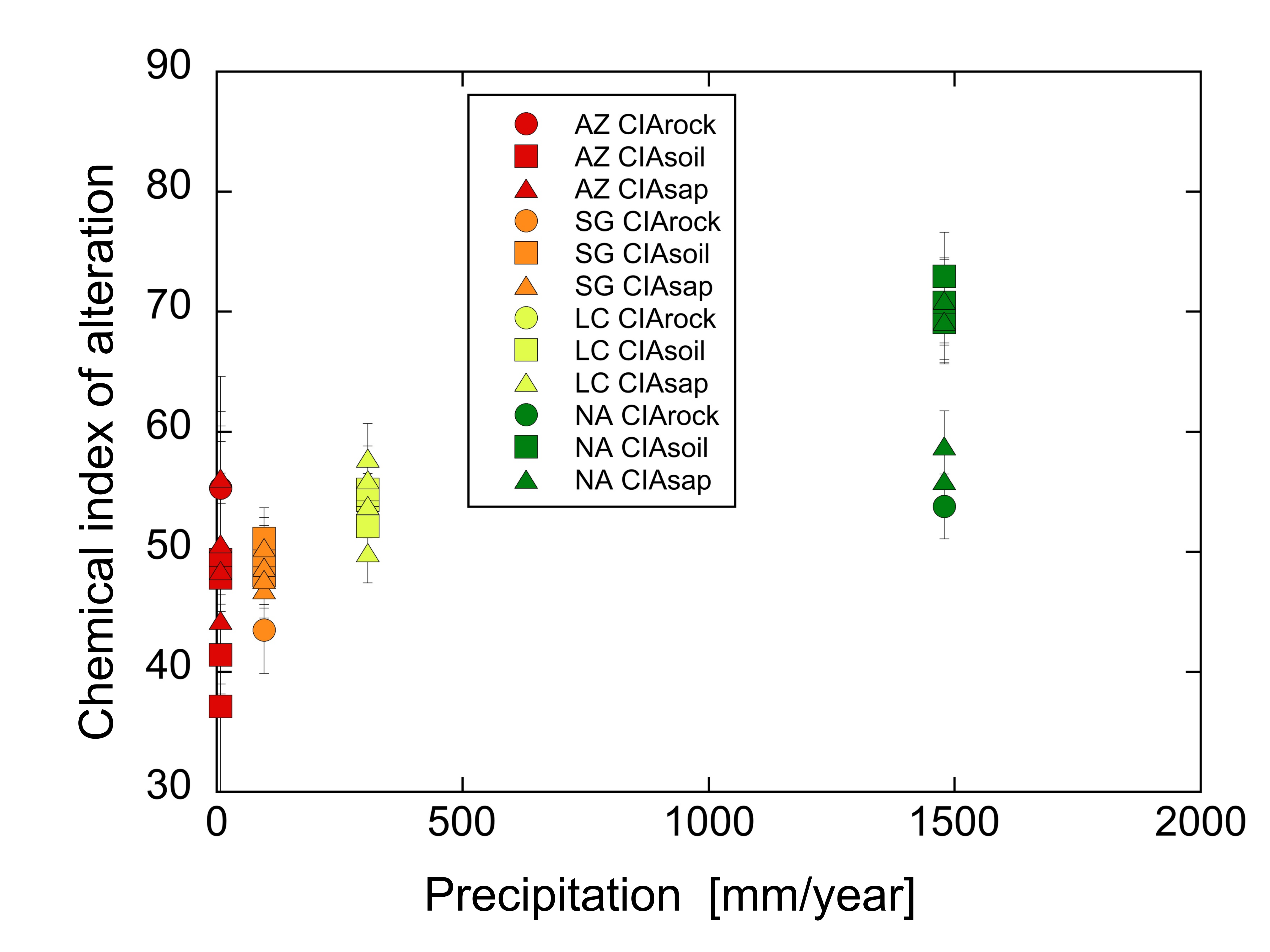
Take home message: High amount of precipitation does not result in high weathering rates.

Chemical index of alteration vs. precipitation



Chemical index of alteration (CIA):

- $CIA = \frac{Al_2O_3}{Al_2O_3 + CaO + Na_2O + K_2O} \times 100$
- **Unweathered granitic rock: CIA = 45 to 55**
- **Completely weathered rock: CIA = 100**

Soils in the Chilean Coastal Cordillera:

- **Arid area: Atmospheric input**
- **Intermediate areas: slight chemical alteration**
- **Humid area: heavy chemical alteration**

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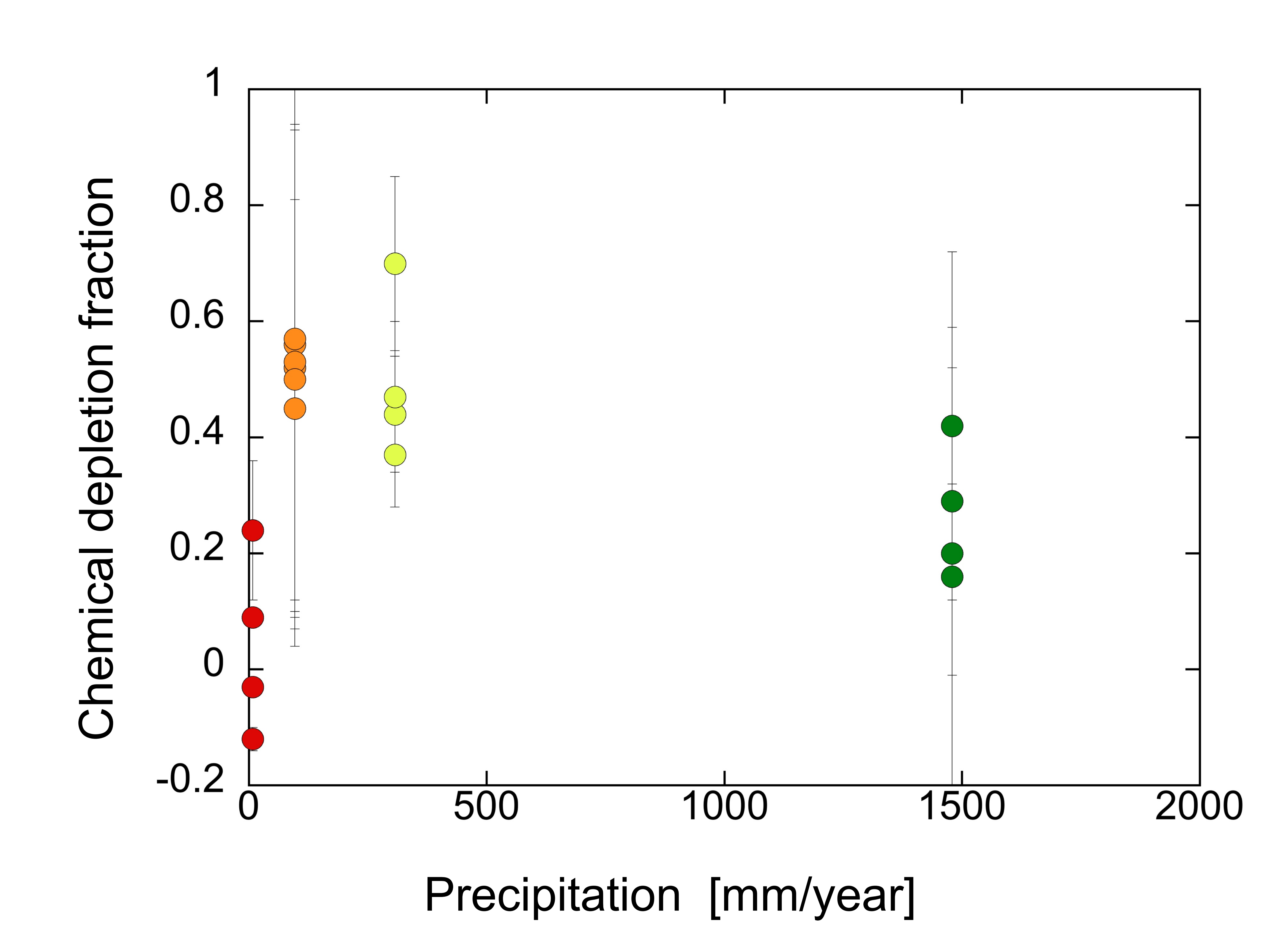
Take home message: CIA of soil is higher in humid than arid areas

Chemical depletion fraction vs. precipitation



Chemical depletion fraction (CDF):

- $CDF_{total} = \frac{W_{total}}{D}$
- **Chemical = physical loss: CDF = 0.5**
- **Chemical < physical loss: CDF < 0.5**

Soils in the Chilean Coastal Cordillera:

- **Arid area: low chemical loss**
- **Intermediate areas: balanced loss**
- **Humid area: low chemical loss, high physical loss or loss of immobile elements due to heavy weathering?**

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Take home message: Heavily weathered soil protects underlying saprolite and diminishes soil production as well as total denudation rates.

Conclusions

Problem addressed:

What governs soil production, chemical weathering, and physical erosion rates:

1. Geology?
2. Climate?
3. Vegetation?

- **Soil production rates are: higher with higher slopes; increase up to ~700 mm/yr precipitation, and then decrease at higher precipitation rates. Potential vegetation effect damps soil production at humid areas.**
- **Soil weathering and physical erosion increase with increasing precipitation.**
- **Vegetation seems to stabilize slopes and decrease denudation rates**

⇒ **Complex interplay between all factors – most interesting result is the decrease in soil production at higher precipitation rates where there is also higher vegetation cover.**

References

Oeser et al., Oeser, R.A., Stroncik, N., Moskwa, L.-M.. Bernhard, N., Schaller, M., Canessa, R., van der B Rin, L., Köster, M., Brucker, E., Stock, SS., Fuentes, J..P., Godoy, R., Matus., F.J., Oses Pedraza, R., Osses McIntyre, P., Paulino, L., Seguel, O., Bader, M.Y., Boy, J., Dippold, M.A., Ehlers, T.a., Kühn, P., Kuzyakiv, Y., Peinweber, P., Scholten, T., Spielvogel, S., Spohn, M., Üubernickel, K., Tielbörger, K., Wagner, D., and von Blanckenburg, F. Chemistry and microbiology of the Critical Zone along a steep climate and vegetation gradient in the Chilean Coastal Cordillera, Ctena, 170, 183-203, 2018.

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