

Building the Map of Life: Improved Environmental Data for Biodiversity Studies



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March 5, 2013

Understanding and Predicting the Biotic Response to Climate Change

...high confidence that climate change will result in extinction of many species and reduction in the diversity of ecosystems¹



¹ IPCC AR4 19.3.4 Ecosystems and biodiversity

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$$\text{Biodiversity} \sim f(\text{Environment})$$

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- Species Distribution Modeling (where do species live?)
- Demographic Models (how do populations respond?)
- Physiological Studies (put frogs in boiling water?)

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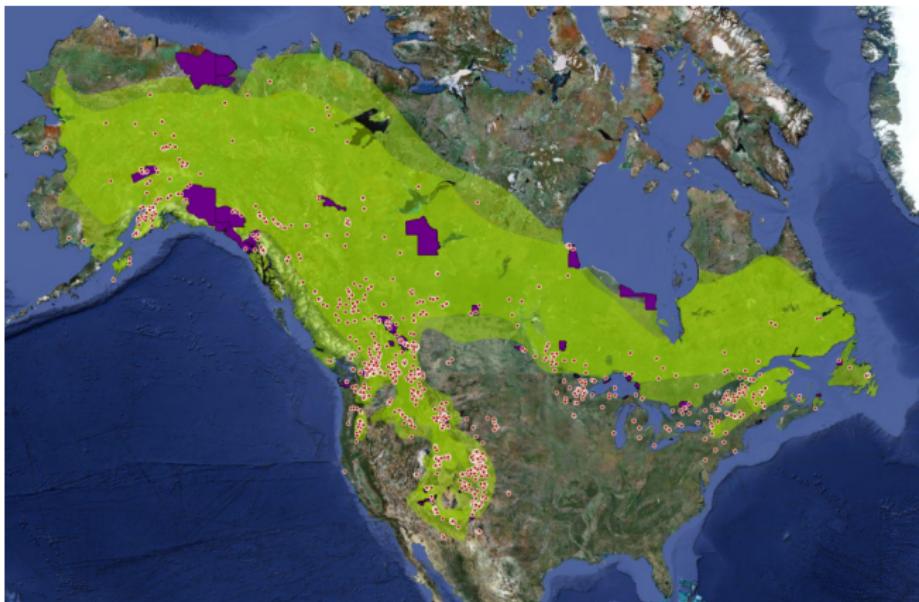
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Map of Life (mappinglife.org): Gathering Global Biodiversity Data

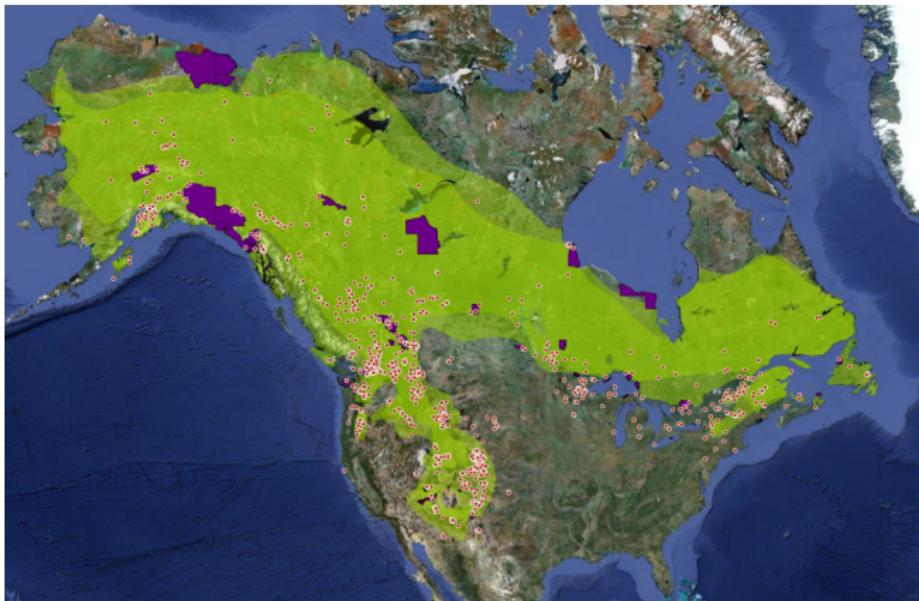
150m records for 50k species



e.g. American Three-toed Woodpecker (*Picoides dorsalis*)

Map of Life (mappinglife.org): Gathering Global Biodiversity Data

Biodiversity $\sim f(\text{Environment})$



e.g. American Three-toed Woodpecker (*Picoides dorsalis*)

Biodiversity
oo

Climate Data
●oo

Station-Satellite Fusion
ooo

Preliminary Results
ooo

High Resolution Environmental Data: Climate Surfaces

$$\text{Biodiversity} \sim f(\text{Environment})$$

Biodiversity
oo

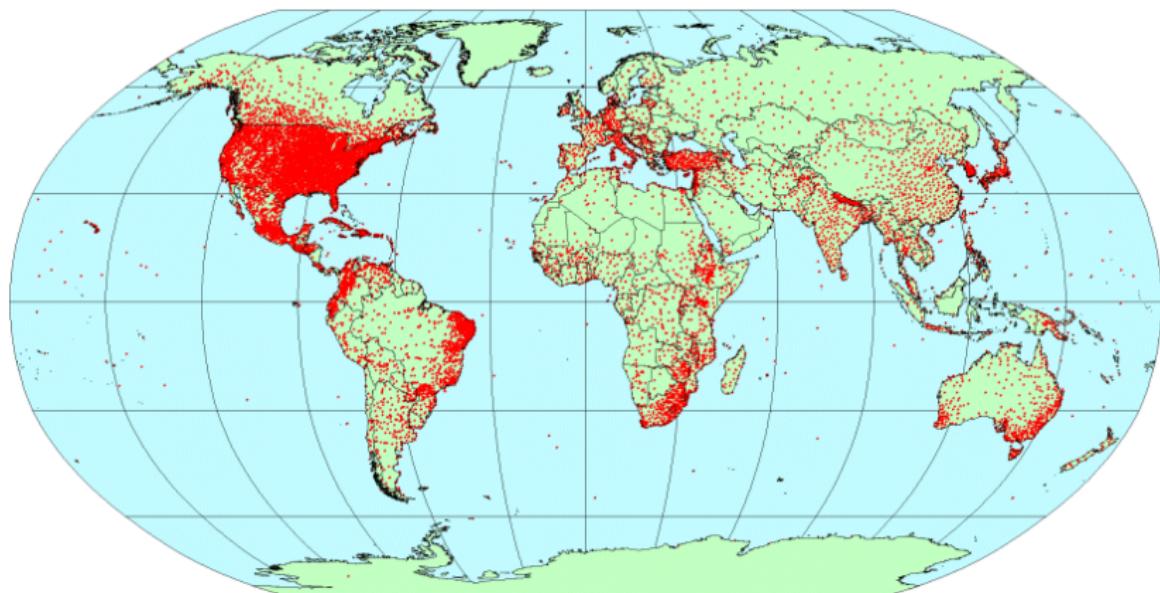
Climate Data
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High Resolution Environmental Data: Climate Surfaces

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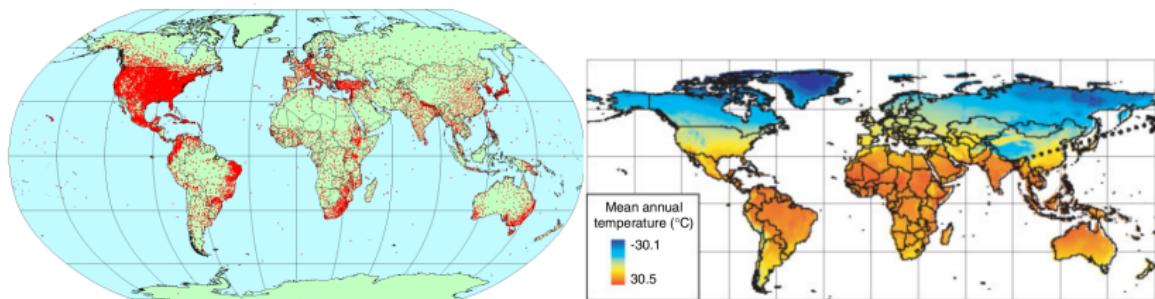
Global Weather Station Network

High Resolution Climate Surfaces: WorldClim²

Station Locations

→

Continuous Grid

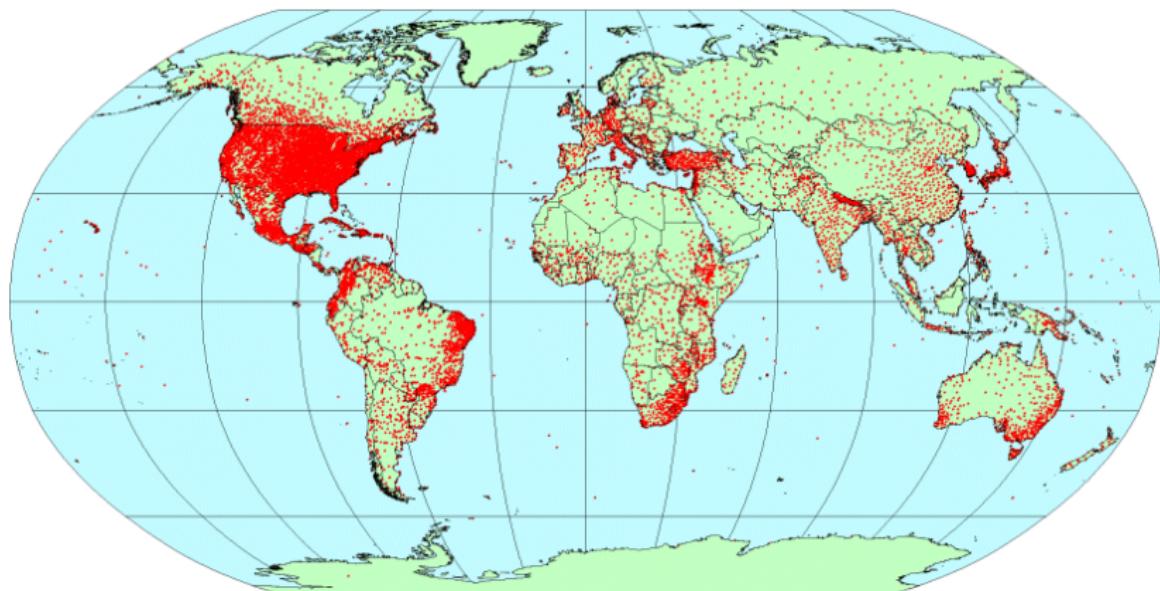


- Global $\approx 1\text{km}$ resolution monthly T_{max} , T_{min} , and PPT.
- 6,500+ citations since 2005

²

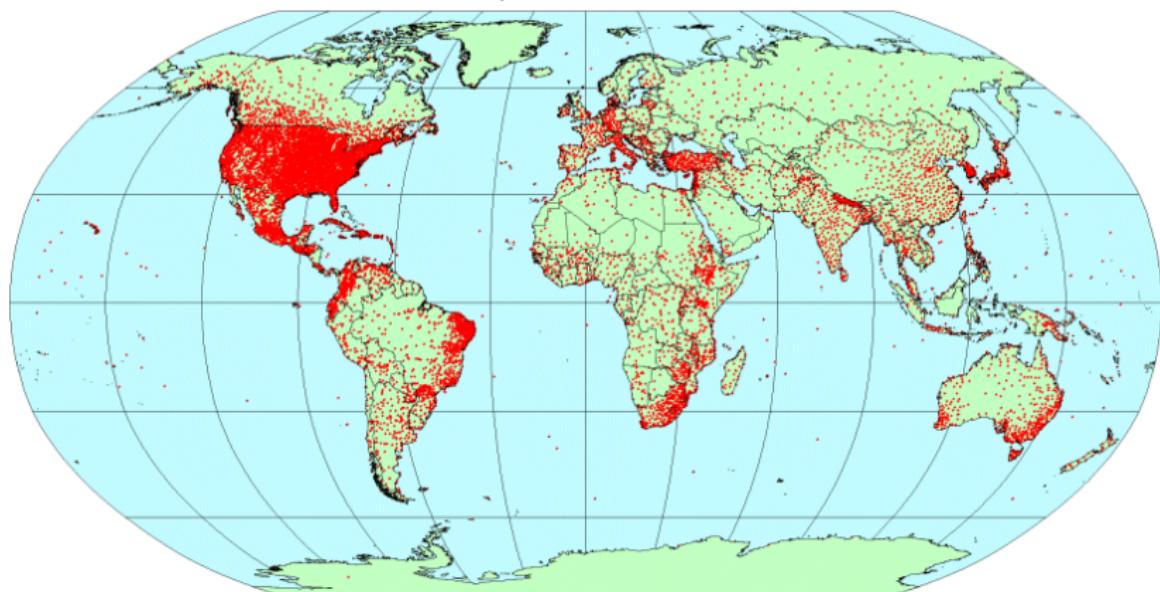
International Journal of Climatology (2005). 25(15):1965–1978

High Resolution Climate Surfaces: WorldClim



Global Weather Station Network

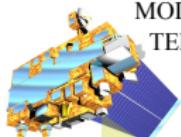
High Resolution Climate Surfaces: WorldClim



Global Weather Station Network

Can satellite observations help fill the gaps?

MODIS Satellite Cloud Data



MODIS Sensor aboard
TERRA and AQUA

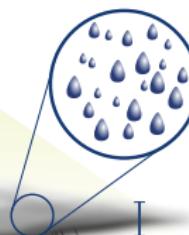
Binary Cloud
Mask (MOD35)

0000111111

Continuous Cloud
Metrics (MOD06)

Particle
Effective
Radius (μm)

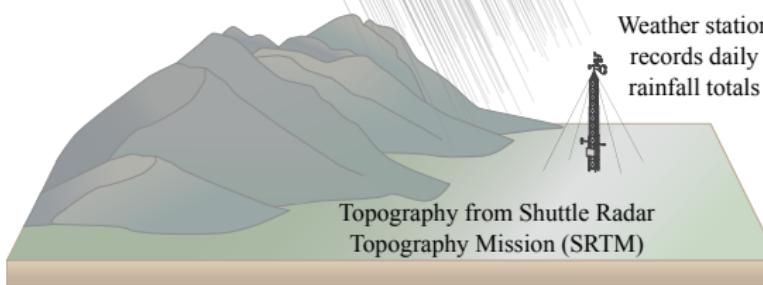
Cloud Optical
Thickness (%)



I

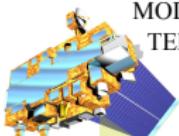
Weather station
records daily
rainfall totals

Topography from Shuttle Radar
Topography Mission (SRTM)



MODIS Satellite Cloud Data

≈140TB



MODIS Sensor aboard
TERRA and AQUA

Binary Cloud
Mask (MOD35)
000011111

Continuous Cloud
Metrics (MOD06)

Particle
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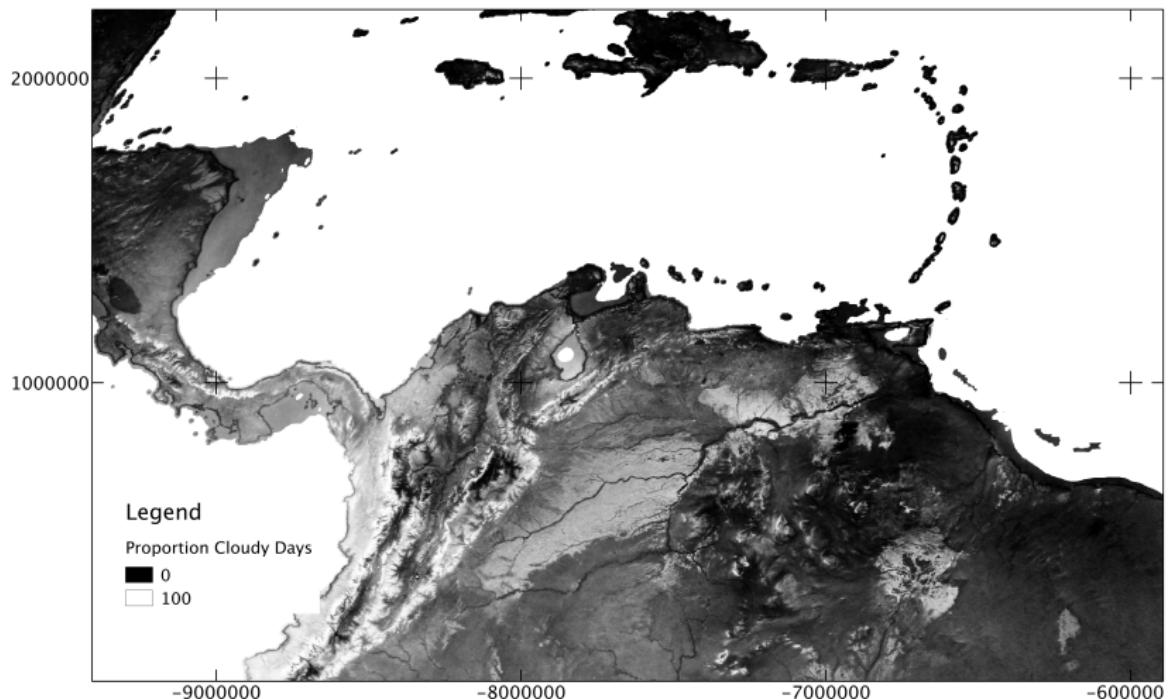
Cloud Optical
Thickness (%)



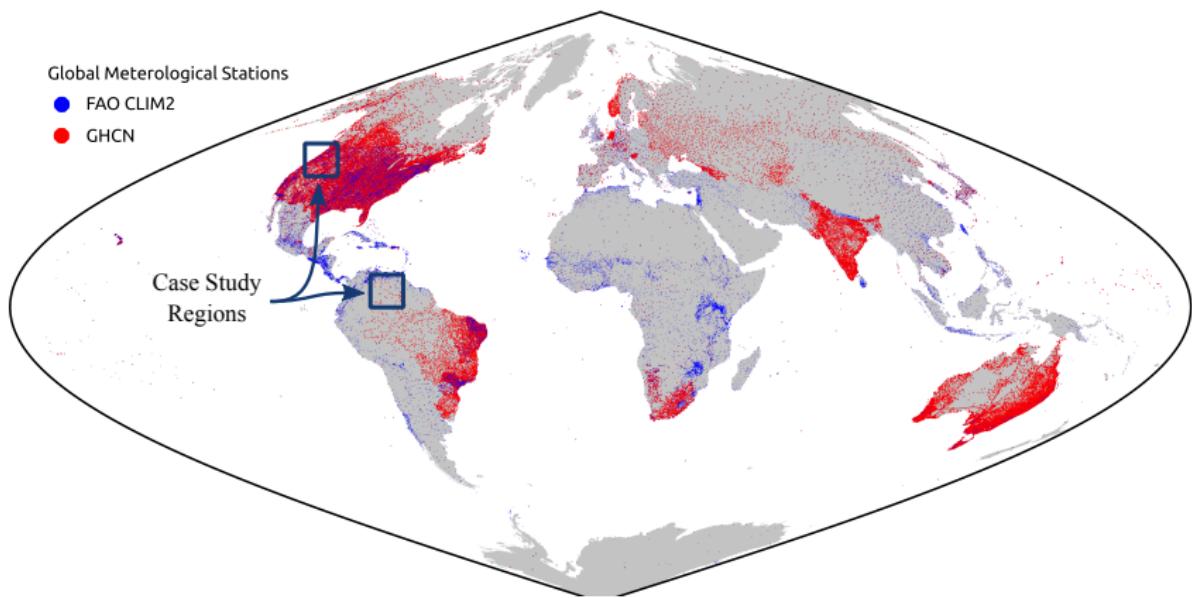
Pleiades
Supercomputer

Topography from Shuttle Radar
Topography Mission (SRTM)

Frequency of Cloudy Days (%)



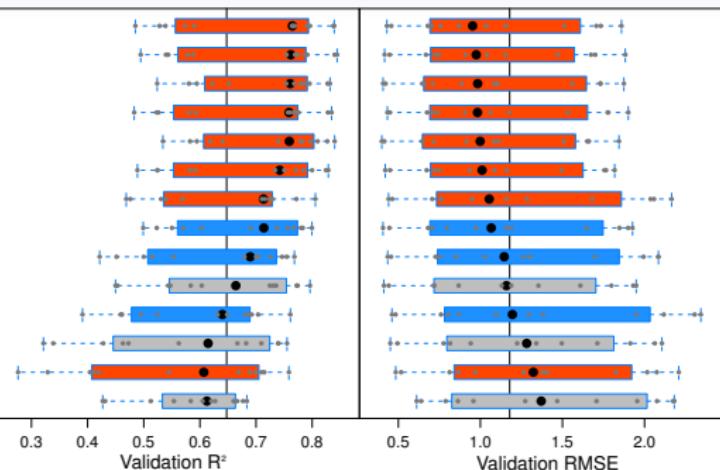
Case Studies: Oregon and Venezuela³



Model Formula

$\text{lppt} \sim s(y,x) + s(\text{dem}) + s(\text{cld}, \text{cot}, \text{cer20})$
 $\text{lppt} \sim s(y,x) + s(\text{dem}) + s(\text{cld}) + s(\text{cot}) + s(\text{cer20})$
 $\text{lppt} \sim s(y,x, \text{dem}) + s(\text{cot})$
 $\text{lppt} \sim s(y,x) + s(\text{dem}) + s(\text{cot})$
 $\text{lppt} \sim s(y,x, \text{dem}) + \text{cld} + \text{cot} + \text{cer20}$
 $\text{lppt} \sim s(y,x) + s(\text{dem}) + \text{cld} + \text{cot} + \text{cer20}$
 $\text{lppt} \sim s(y,x) + s(\text{cot})$
 $\text{lppt} \sim s(y,x, \text{dem}) + s(\text{cld})$
 $\text{lppt} \sim s(y,x) + s(\text{cld})$
 $\text{lppt} \sim s(y,x) + s(\text{dem})$
 $\text{lppt} \sim s(y,x) + s(\text{cer20})$
 $\text{lppt} \sim s(y,x)$

Pacific Northwest (h09v04)

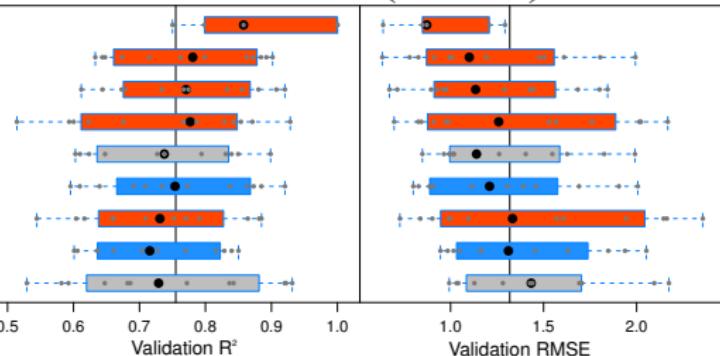


Improved Predictive Accuracy

MOD06
MOD35
Spatial

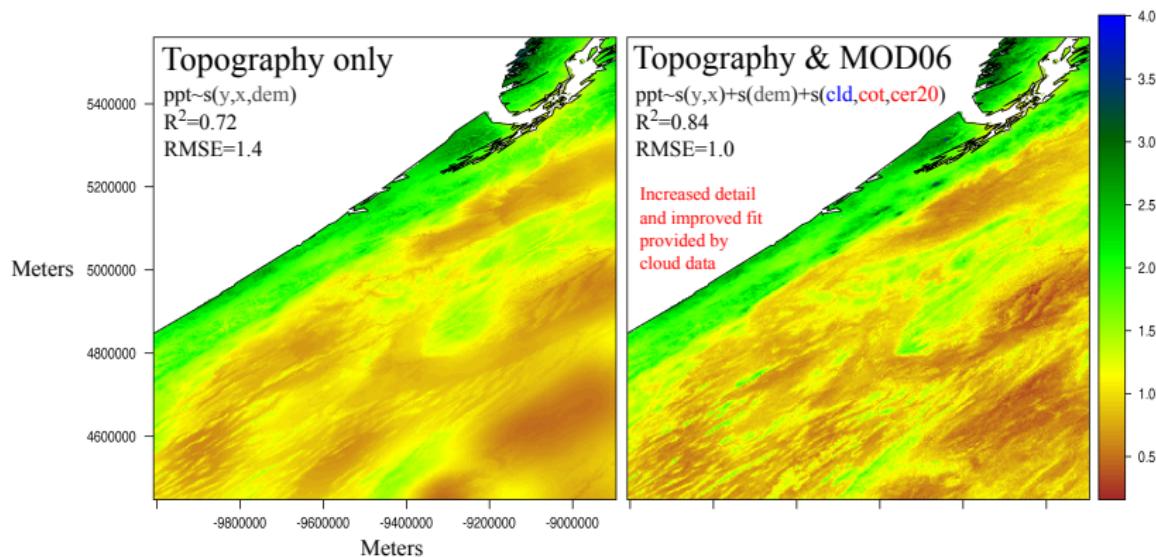
Venezuela (h11v08)

$\text{lppt} \sim s(y,x) + s(\text{dem}) + s(\text{cld}) + s(\text{cot}) + s(\text{cer20})$
 $\text{lppt} \sim s(y,x) + s(\text{cer20})$
 $\text{lppt} \sim s(y,x) + s(\text{cot})$
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 $\text{lppt} \sim s(y,x) + s(\text{dem}) + s(\text{cld})$
 $\text{lppt} \sim s(y,x)$



Improved Predictive Accuracy

MODIS Cloud → Improved Predictions & Spatial Detail



Predictions for mean March precipitation (H09V04) using a GAM with elevation (left) and MOD06 cloud parameters (right).

Summary & Next Steps

Summary:

1. Global high-resolution environmental data vital for assessing biotic response to climate change
2. Satellite observations improve climate interpolations

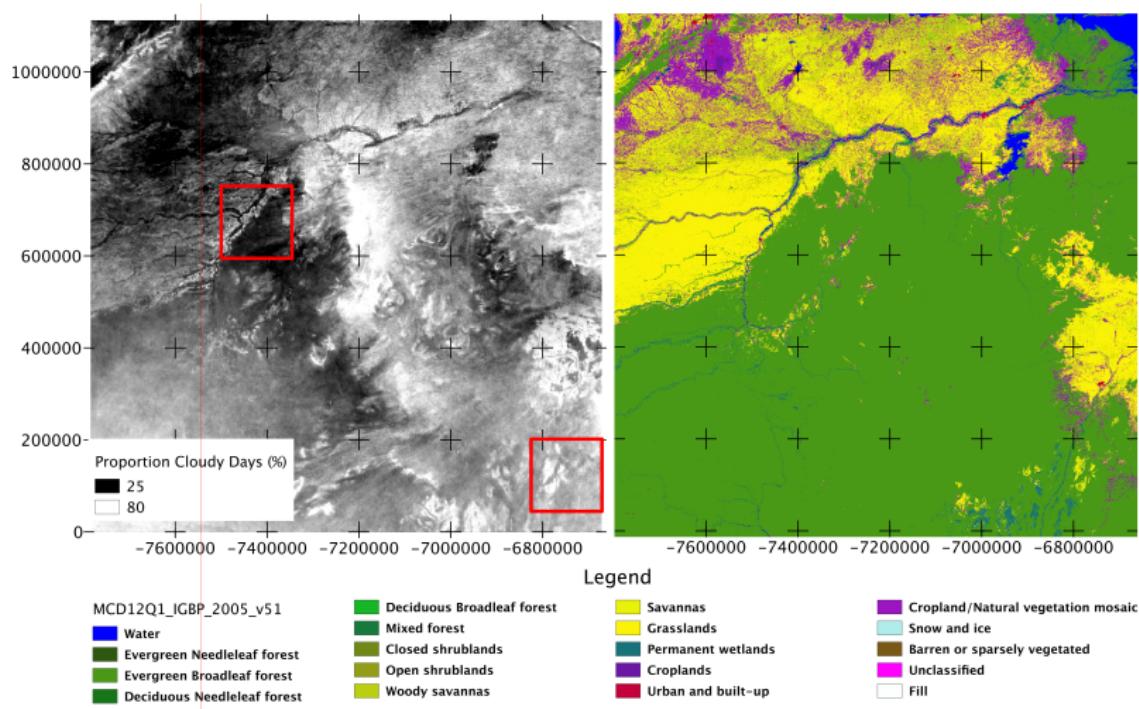
Next Steps:

- More test regions → global analysis
-  NCEAS Global Layers Project
- Map Of Life: distributional data → multi-scale models

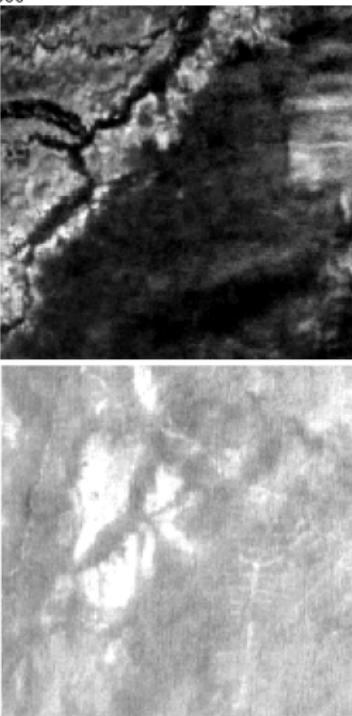
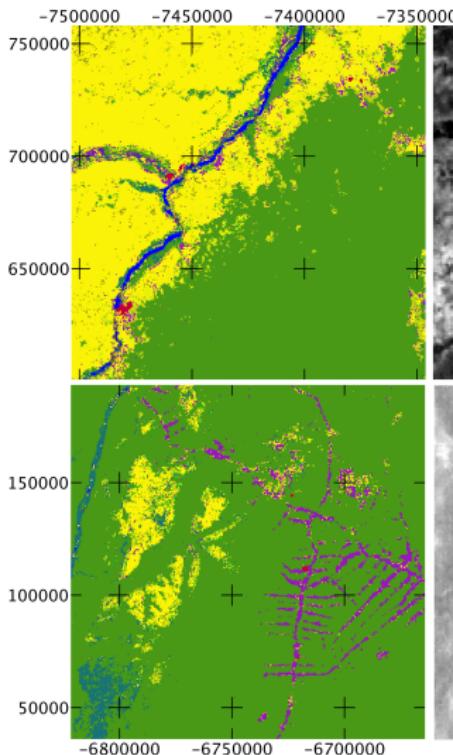
Do cloud metrics improve predictive accuracy?

- Monthly climatologies from GHCN
- H09V04 (Oregon) and H11V08 (Venezuela)
- GAMs including X, Y, & elevation, plus MOD35 and MOD06
- Validation: repeated random 10% sub-sampling → R^2 & RMSE.

MODIS Cloud Mask Landcover Bias (Venezuela)



MODIS Cloud Mask Landcover Bias (Venezuela)



Legend

CLDO

25

80

MCD12Q1_IGBP_2005_v51

Water

Evergreen Needleleaf forest

Evergreen Broadleaf forest

Deciduous Needleleaf forest

Deciduous Broadleaf forest

Mixed forest

Closed shrublands

Open shrublands

Woody savannas

Savannas

Grasslands

Permanent wetlands

Croplands

Urban and built-up

Cropland/Natural vegetation mosaic

Snow and ice

Barren or sparsely vegetated

Unclassified

Fill

MODIS Cloud Mask Landcover Bias (Venezuela)

