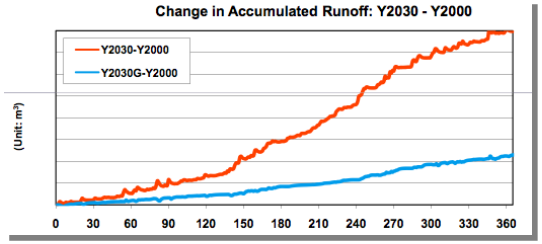
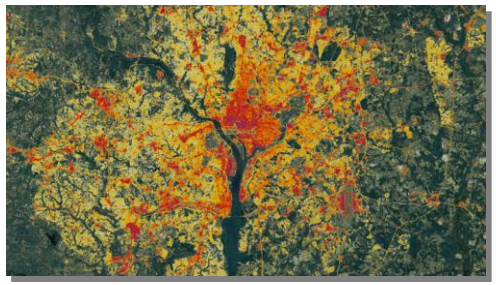
Modeling Strategies for Adaptation to Coupled Climate and Land Use Change in the United States





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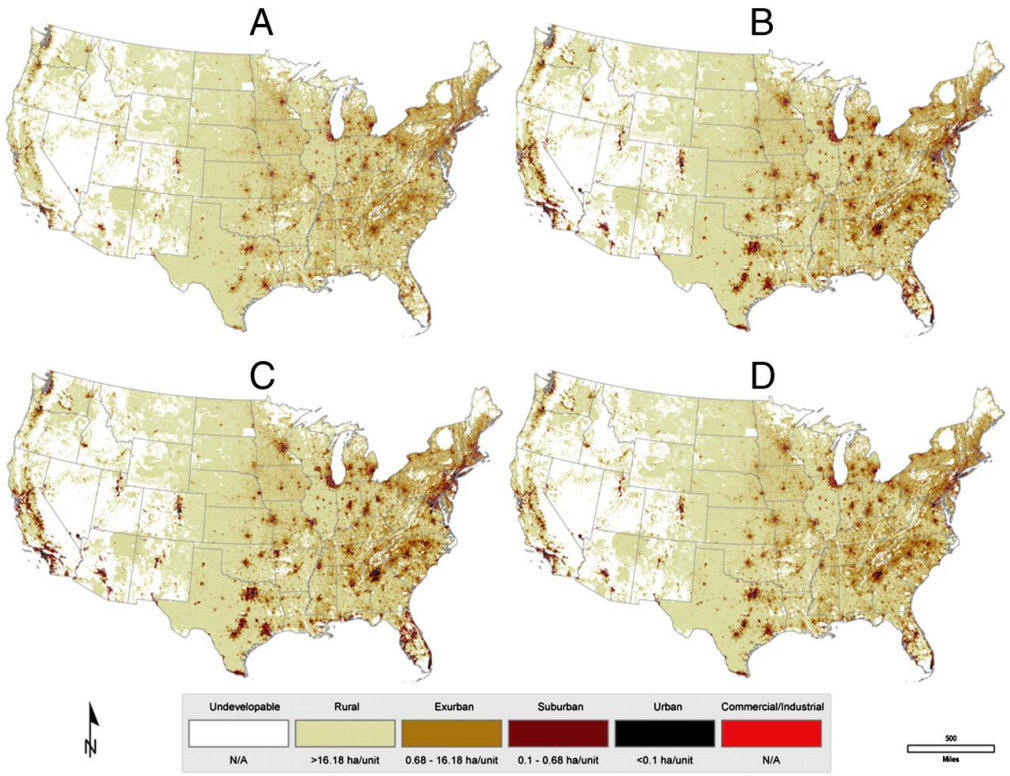
Motivation

- IPCC Fourth Assessment Report (AR4) projects warming of 4-12 °C over the United States by 2100
- Urban land cover and associated impervious surface are forecasted to increase by 50% over the next few decades across substantial portions of the U.S.
- Coupled effects of changes in climate and land use and land cover are expected to intensify impacts on ecosystems (changes in productivity, disturbance and hydrological properties)
- Low impact development (LID) and Best management practices (BMPs) for land use planning and design can mitigate impacts resulting from changes in climate and LU (e.g. reducing impervious surface cover)

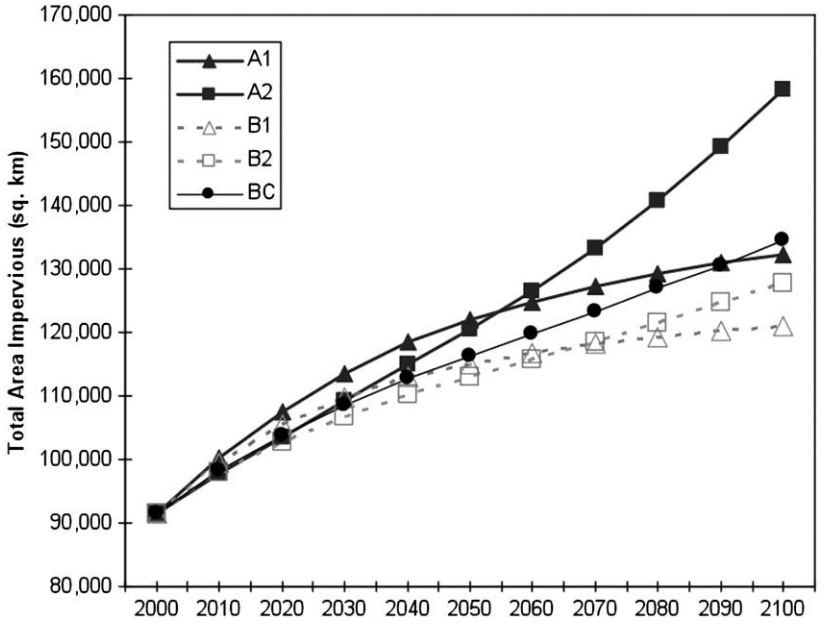
Goal and Objectives

- Prepare for next generation regionally focused IPCC scenarios that better incorporate the influences of land use change by:
  - Spatially predict future land use changes
  - Incorporate land use and climate change predictions under different SRES scenarios into ecosystem process models
  - Simulate the influence of potential mitigation and adaptation actions by predicting land use change scenarios that incorporate a range of best management practices (BMPs) associated with land cover and land use change.

Methods: SERGoM Housing Density ⇒ Impervious



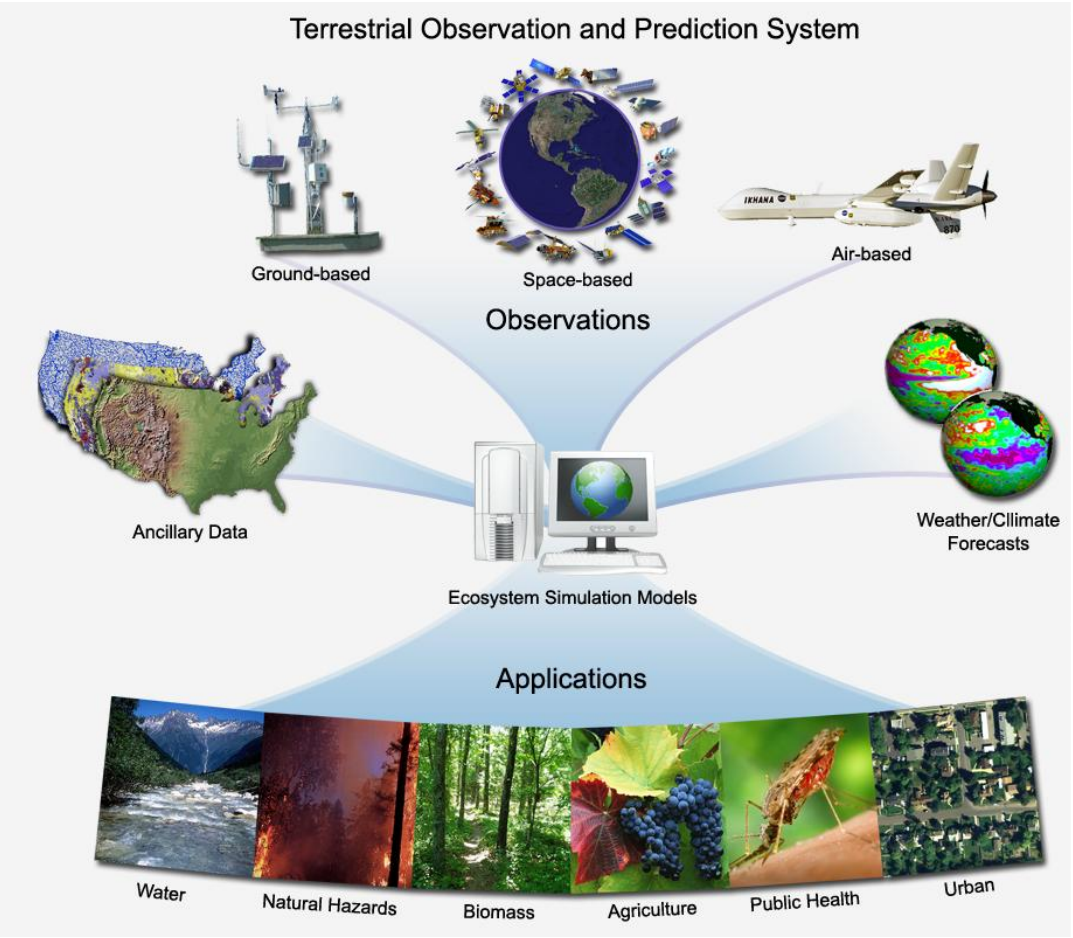
Area covered by impervious surface over time for all five scenarios.



(A) actual housing density in 2000; (B) modeled housing density in 2100 for base case; (C) for scenario A2; and (D) for scenario B1.

Bierwagen et al. PNAS 2010;107:20887-20892

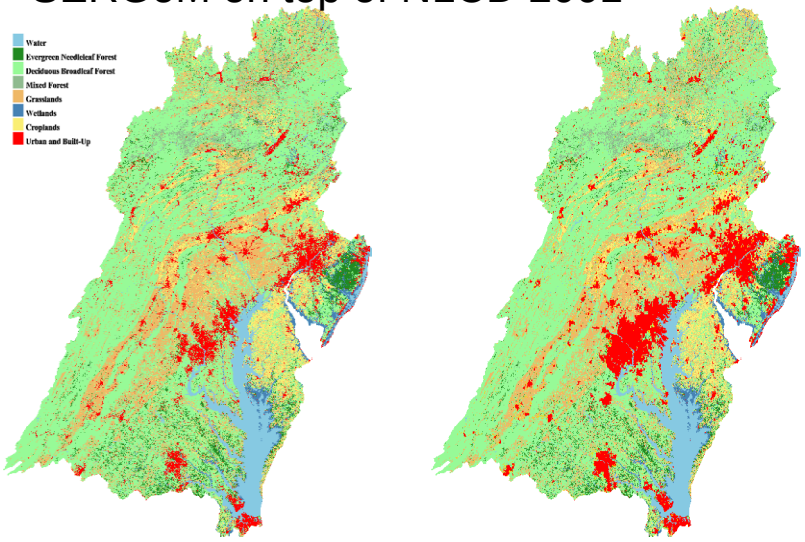
Methods: TOPS



Input Parameter	Chesapeake / Delaware (250m)	United States (1km)
Impervious surface area	SERGoM (Theobald et al., 2009)	
Climate (baseline run)	TOPS-SOGS Weather Surfaces	
Climate (forecast)	WCRP CMIP3 (Maurer et al., 2007) GFDL CM2.0, NCAR CCSM3.0, GISS-ER Scenarios A1B, A2, B1	
Elevation	National Elevation Dataset (resampled)	
Leaf Area Index (baseline run)	MODIS MOD13Q1 NDVI and MOD15A2 LAI algorithm	MODIS MOD15A2 LAI (Myneni et al., 2000)
Leaf Area Index (forecast)	MODIS MOD15A2 LAI Climatology	Simulated by BIOME-BGC
Soils	U.S. STATSGO2 database	
Land Cover	NLCD2001 (Homer et al., 2004) Cross-walked to IGBP	MODIS MOD12Q1 Land cover (Friedl et al., 2002)

Model Calibration: Land Cover Change Impacts

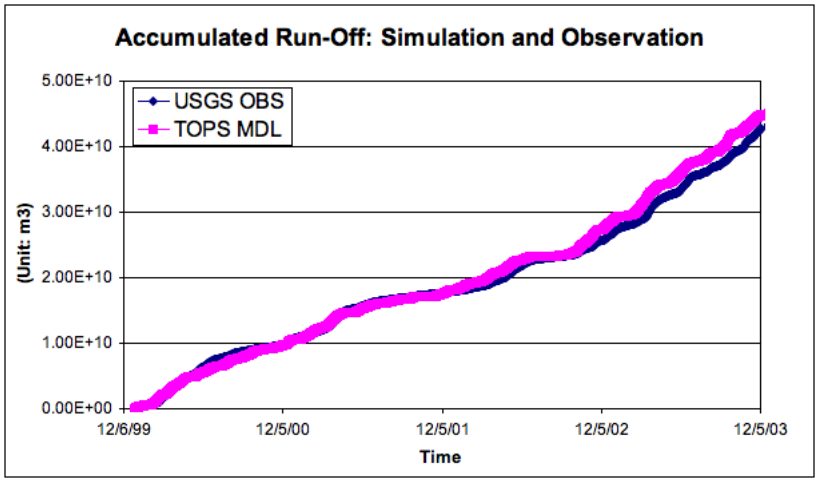
Current and Projected Impervious cover
SERGoM on top of NLCD 2001

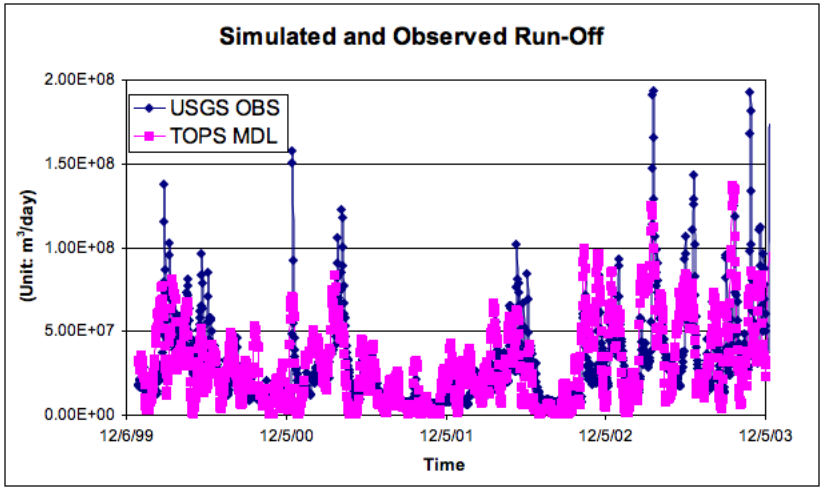


Baseline
LC (2000)

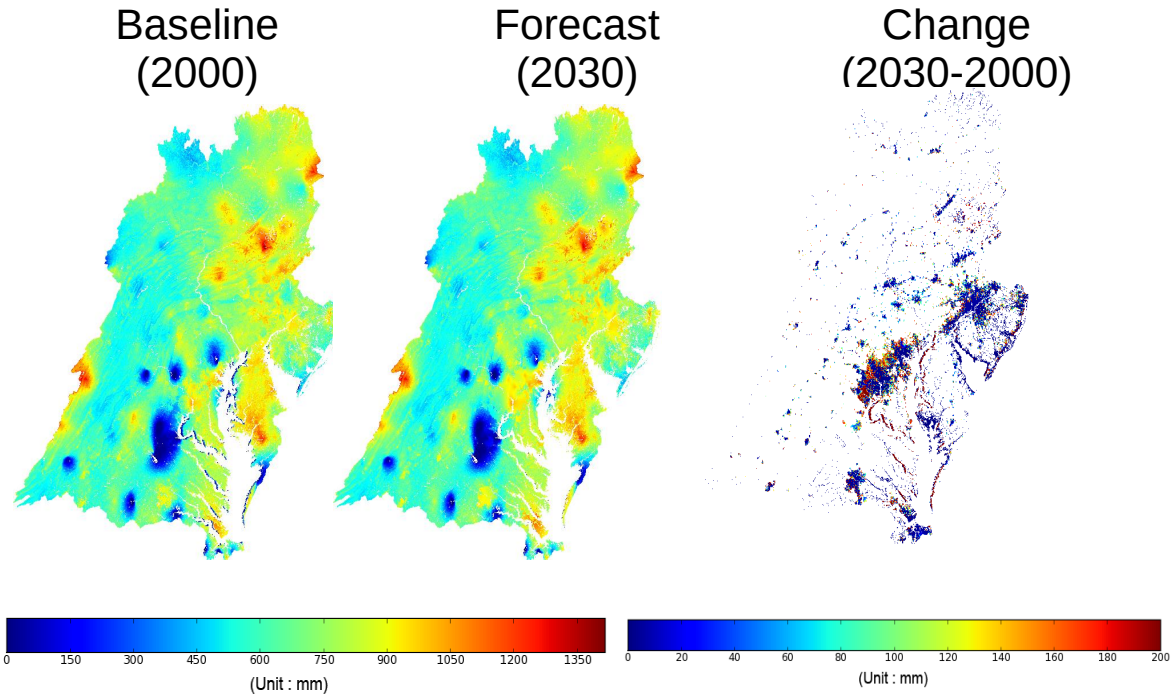
Forecast
LC (2030)

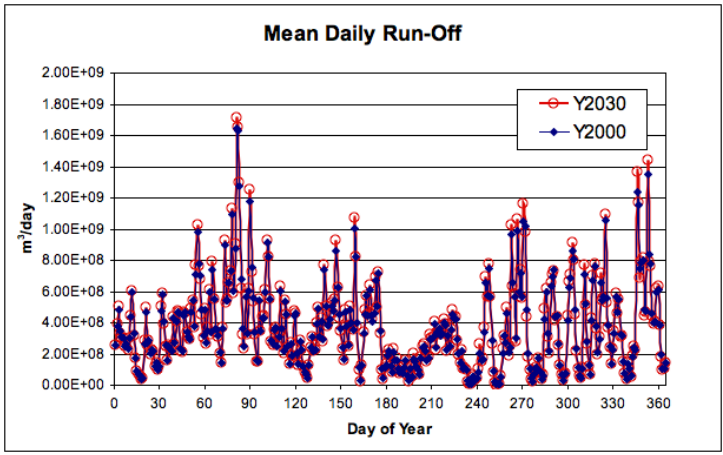
Chesapeake Bay and Delaware River watersheds

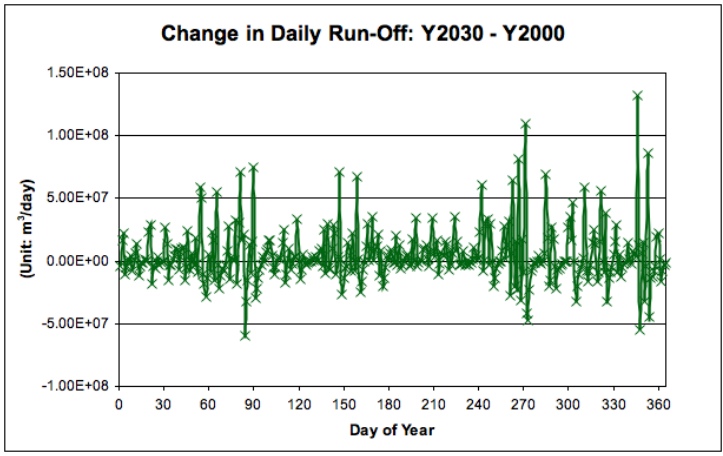




TOPS Results: Impact of Land Use Change on Runoff







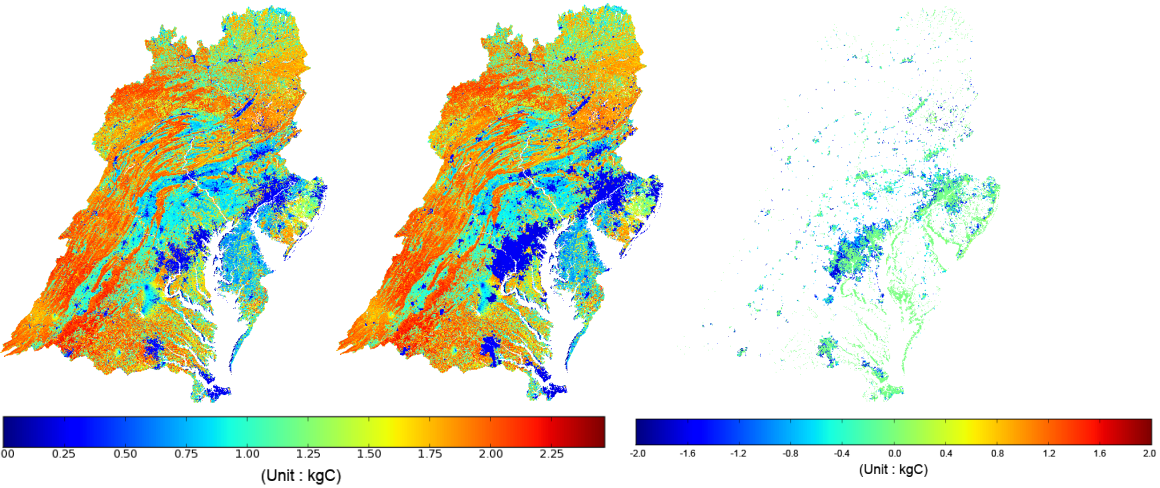
Average annual total runoff for the baseline (2000) and forecast (2030) scenarios, and the projected *increase* in average annual runoff

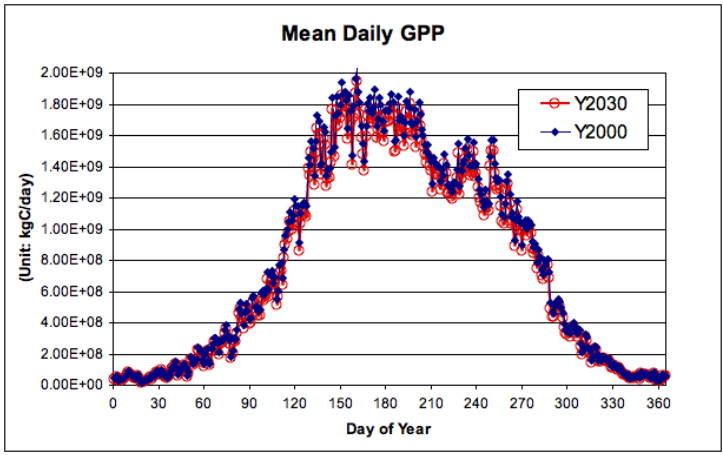
TOPS Results: Impact of Land Use Change on Vegetation Productivity

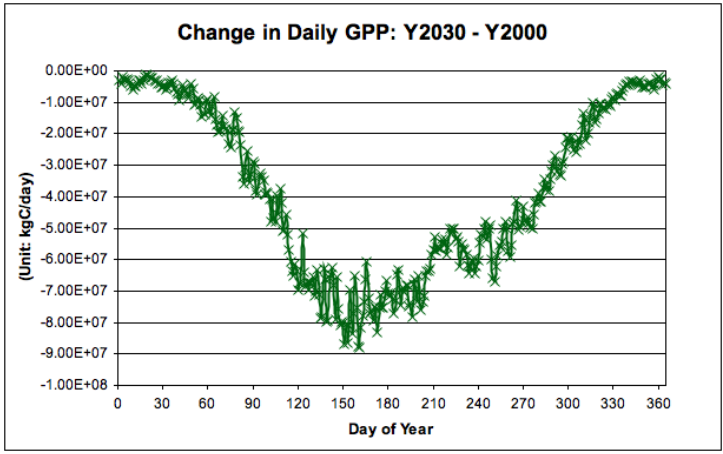
Baseline (2000)

Forecast (2030)

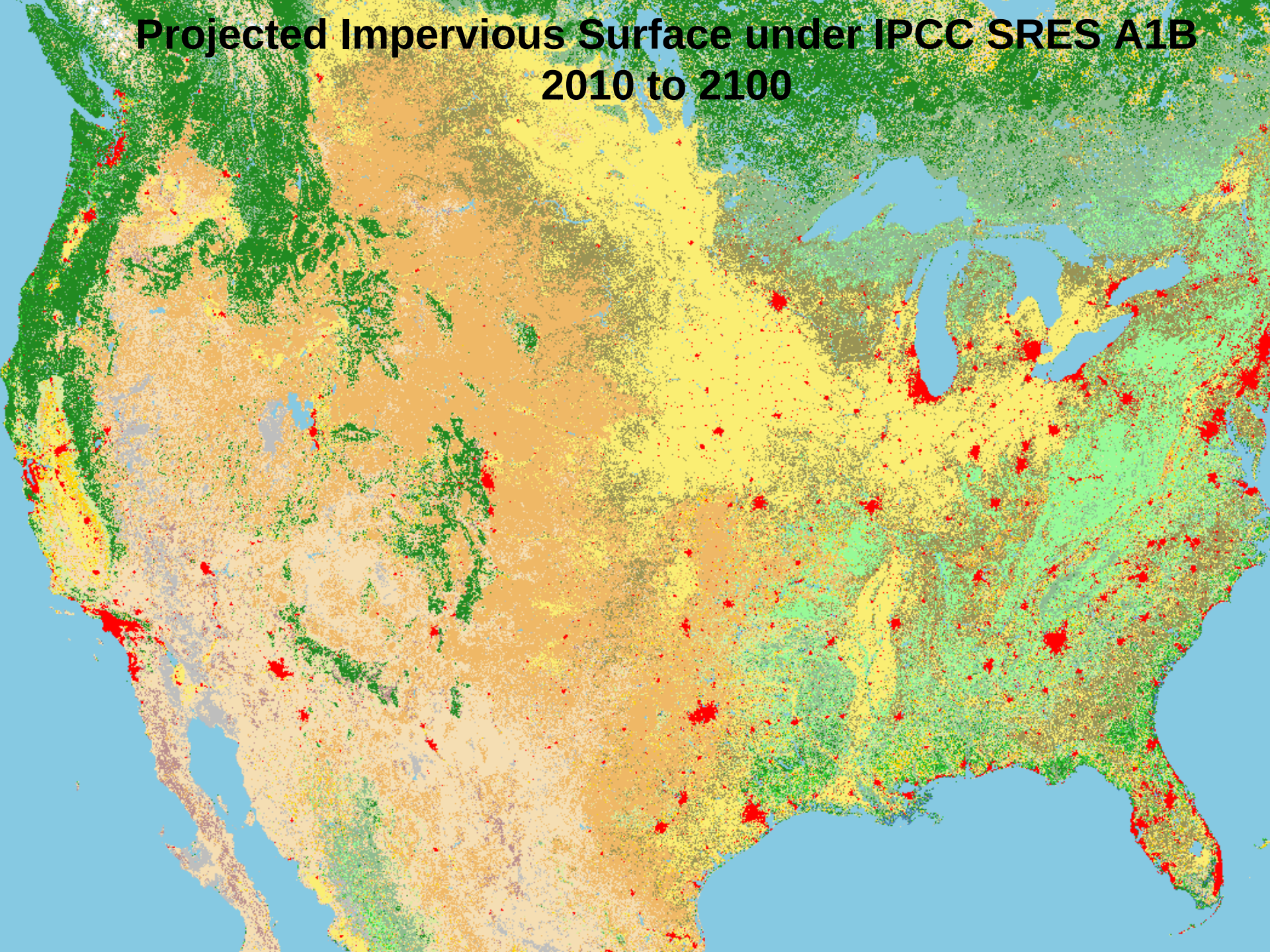
Change 2030-2000





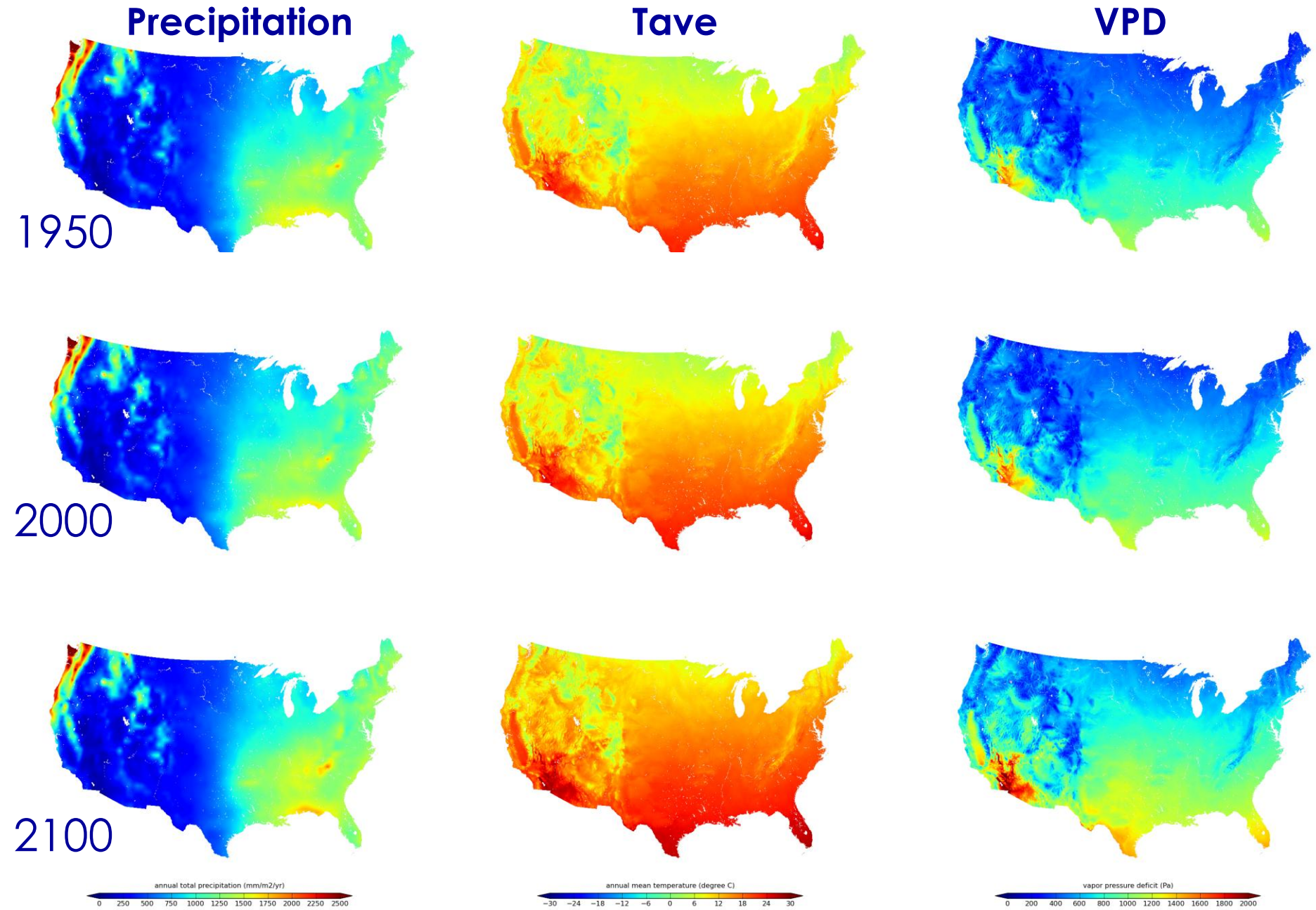


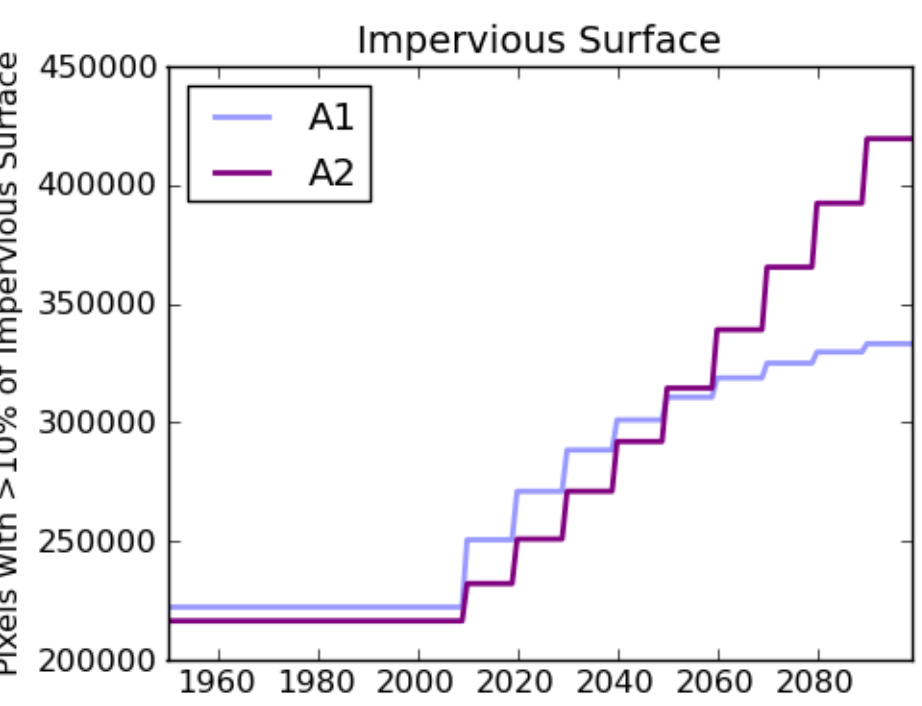
Projected Impervious Surface under IPCC SRES A1B
2010 to 2100

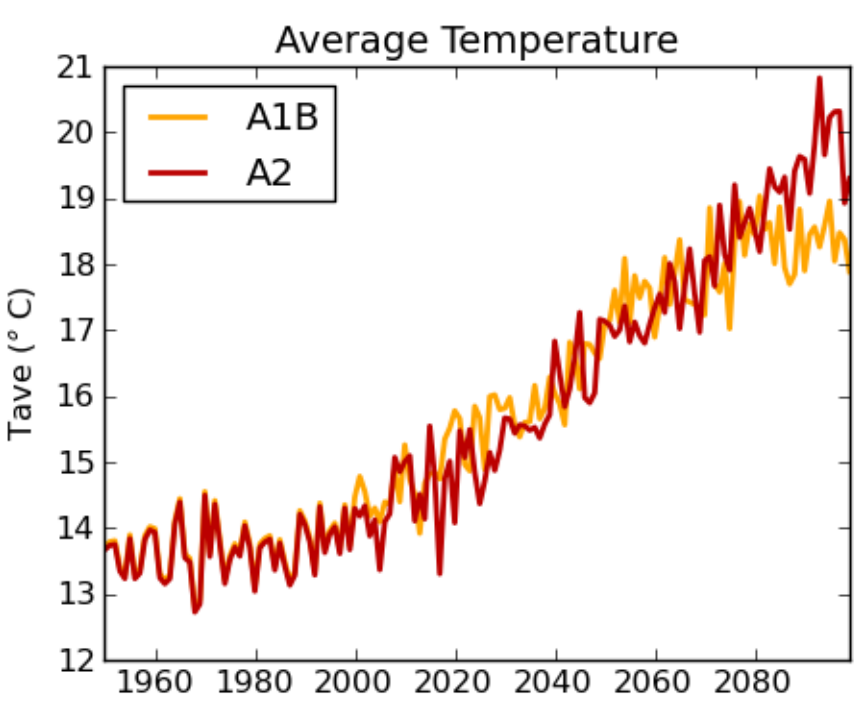


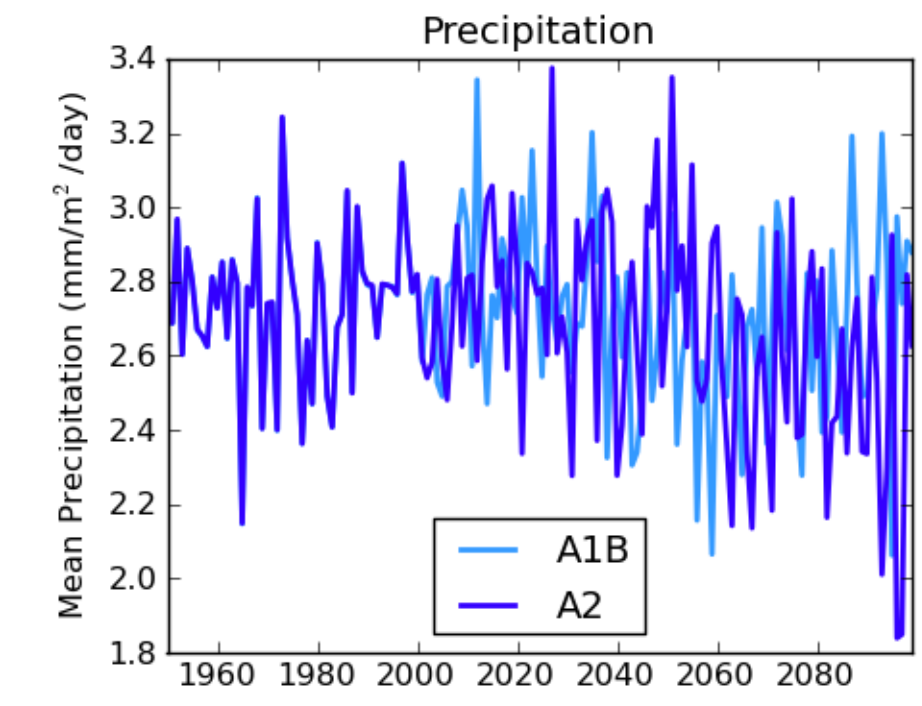
Projected Climate under IPPCC SRES A1B

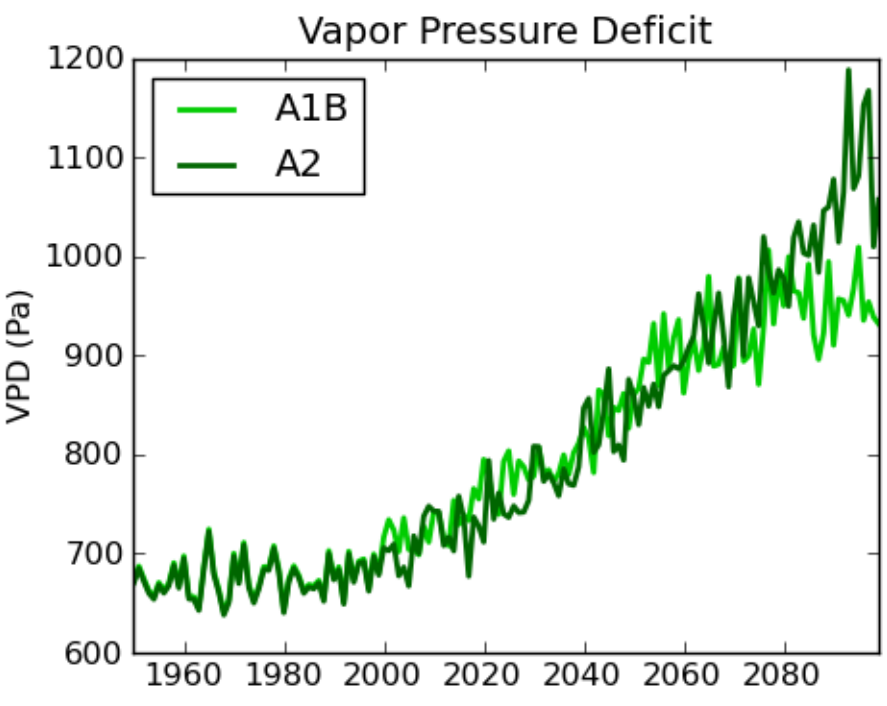
1km Downscaled GFDL CM2.0




Impervious Surface
Pixels with >10% of Impervious Surface
A1
A2
450000
400000
350000
300000
250000
200000
1960
1980
2000
2020
2040
2060
2080

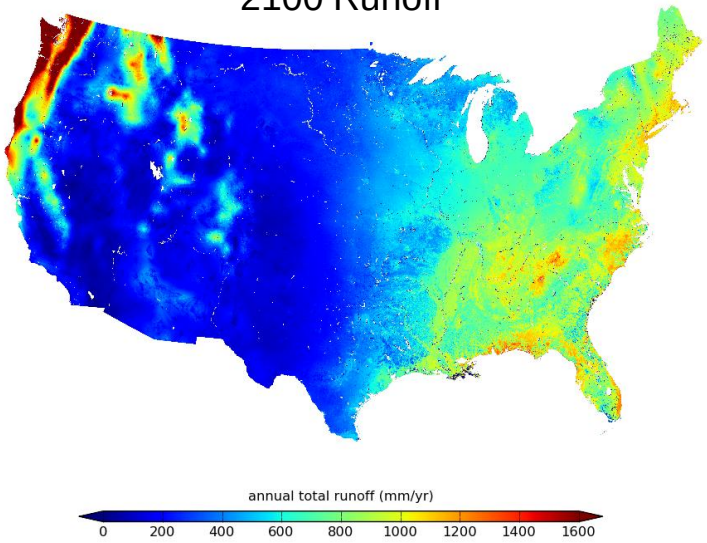

Average Temperature
Tave (° C)
A1B
A2
21
20
19
18
17
16
15
14
13
12
1960
1980
2000
2020
2040
2060
2080


Precipitation
Mean Precipitation (mm/m^2 /day)
A1B
A2
3.4
3.2
3.0
2.8
2.6
2.4
2.2
2.0
1.8
1960
1980
2000
2020
2040
2060
2080

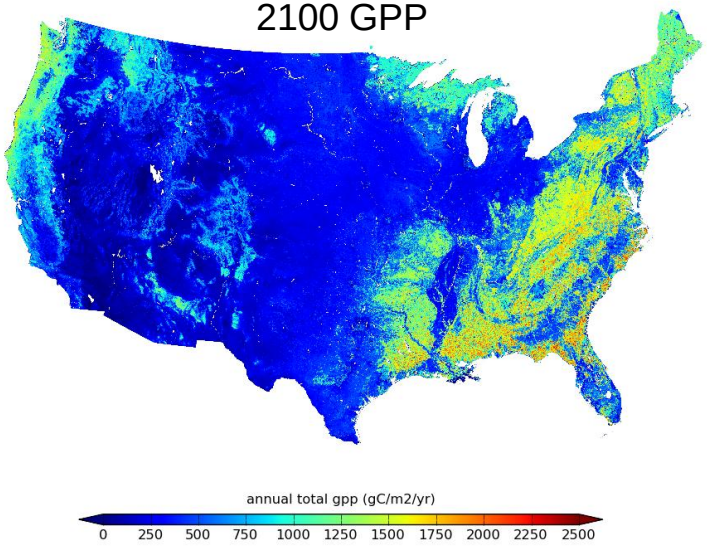

Vapor Pressure Deficit
VPD (Pa)
A1B
A2
1200
1100
1000
900
800
700
600
1960
1980
2000
2020
2040
2060
2080

TOPS Results: Coupled Climate and Land Use Change

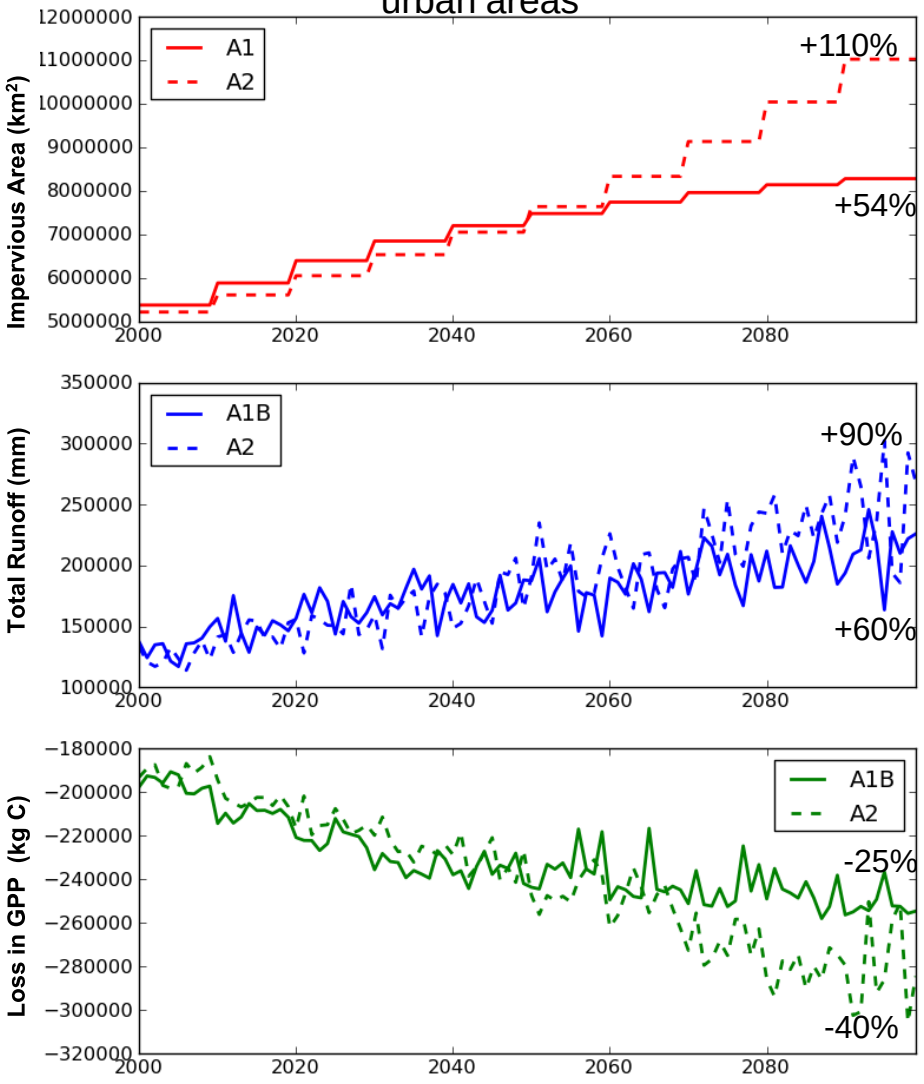
2100 Runoff



2100 GPP



Coupled climate and land use change impacts over urban areas



Next Steps

- TOPS runs with other ecosystem and climate models (i.e., GISS-ER, CCSM3.0) and SRES B1 and B2
- Regional analysis of impacts of land use changes versus climate
- Assess the effects on runoff and vegetation productivity of realistic Best Management Practices / Low Impact Development techniques by simulating:
  - increases of pervious surfaces
  - green roofs
  - urban afforestation programs



Data Sharing on NASA Earth Exchange

Collaborative computing environment for sharing of data, code and science results

https://c3.ndc.nasa.gov/nex/

NEX Components