Simulating human land cover change in global climate models

Outline

Kansas and climate change

• Background on Kansas Climate
• Kansas Climate over the last century
• Global Climate over the last century
• If we can’t trust the weatherman what about climate projections – How reliable are climate models
• Climate projections
• Climate impacts
Background on Kansas Climate


Kansas Climate over the last century

Temperature trends for Manhattan KS

Precipitation trends for Manhattan KS

Sedan (KS): Mean Precipitation Time Series

Sedan (KS): Mean Temperature Time Series

Sedan (KS): Mean Maximum Temp Time Series

Sedan (KS): Mean Minimum Temp Time Series
Kansas Land Cover Patterns

• 91% overall accuracy

Kansas Climate over the last century
Kansas Climate over the last century

Global Climate over the last century
Global Climate over the last century

Figure 3-6. Global and Hemisphere annual combined land-surface air temperature and SST anomalies (°C) and for 1650 to 2005 relative to the 1941 to 1960 period, along with 1930 to 1950 error bars ranges, from HadCRUT3 (adapted from Branstator et al., 2005). The smooth thick curves show decadal variations (see Appendix 5.6).

How reliable are climate models

Weather forecasts

Climate Predictions
without anthropogenic
and with anthropogenic
influences

Seasonal to interannual (ENSO)

1 day 1 month 1 year 10 years 100 years

Keven Trenberth, NCAR
How reliable are climate models

Caspar Ammann
NCAR/CGD
CO$_2$, CH$_4$ and estimated global temperature (Antarctic $\Delta T/2$ in ice core era) 
$0 = 1880-1899$ mean.


Climate projections

Raupach et al., PNAS, 2007
Climate change experiments from 16 groups (11 countries) and 23 models collected at PCMDI (over 31 terabytes of model data)

Committed warming averages 0.1°C per decade for the first two decades of the 21st century; across all scenarios, the average warming is 0.2°C per decade for that time period (recent observed trend 0.2°C per decade)
Climate projections

Figures based on Tebaldi et al. 2006: Climatic Change, Going to the extremes; An intercomparison of model-simulated historical and future changes in extreme events, http://www.cgd.ucar.edu/ccr/publications/tebaldi-extremes.html
Multi-model average precipitation % change, medium scenario (A1B), representing seasonal precipitation regimes, total differences 2090-99 minus 1980-99

White areas are where less than two thirds of the models agree in the sign of the change
Stippled areas are where more than 90% of the models agree in the sign of the change. Precipitation increases very likely in high latitudes. Decreases likely in most subtropical land regions. This continues the observed patterns in recent trends.

Climate projections

**Climate projections**

**Eastern Kansas (37N, 95W)**

<table>
<thead>
<tr>
<th>Season</th>
<th>D (mm)</th>
<th>S (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Present Day Normal</td>
<td>47</td>
<td>304</td>
</tr>
<tr>
<td>+1°C Summer</td>
<td>69</td>
<td>242</td>
</tr>
<tr>
<td>+2°C Spring and Fall</td>
<td>95</td>
<td>246</td>
</tr>
<tr>
<td>+3°C Winter</td>
<td>123</td>
<td>216</td>
</tr>
</tbody>
</table>

Legend:
- **D** = Annual Deficit (mm)
- **S** = Annual Surplus (mm)

**0.87 Inches drier**

**1.89 Inches drier**

**2.99 Inches drier**
Climate projections
Eastern Kansas (37N, 95W)

Present Day Normal
D = 47
S = 304

- 10% precipitation
D = 98
S = 161
2.00 Inches drier

No Change in Precipitation
D = 69
S = 242
0.87 Inches drier

+10% Precipitation
D = 46
S = 325
0.04 Inches wetter

+ 20% Precipitation
D = 30
S = 418

Climate projections
Western Kansas (37N, 102W)

Present Day Normal
D = 330
S = 0

+ 1 C all months
D = 377
S = 0
1.85 Inches drier

+ 2 C all months
D = 433
S = 0
4.05 Inches drier

+ 3 C all months
D = 484
S = 0
6.00 Inches drier

All temperature scenarios:
+ 1 C Summer
+ 2 C Spring and Fall
+ 3 C Winter

D = Annual Deficit (mm)
S = Annual Surplus (mm)
**Climate projections**

Western Kansas (37N, 102W)

- **D** = Annual Deficit (mm)
- **S** = Annual Surplus (mm)

Present Day Normal

- **D** = 330
- **S** = 0

- 10% precipitation
  - **D** = 455
  - **S** = 0

- No change in precipitation
  - **D** = 412
  - **S** = 0

- +10% precipitation
  - **D** = 366
  - **S** = 0

- +20% precipitation
  - **D** = 322
  - **S** = 0

- +30% precipitation
  - **D** = 300
  - **S** = 0

All temperature scenarios:
- +1 C Summer
- +2 C Spring and Fall
- +3 C Winter

Western Kansas (37N, 102W)

The End
How reliable are climate models
Changes in Sea Ice Coverage

Meehl et al., 2005

Abrupt Transitions in the Summer Sea Ice

5-year running mean

- Gradual forcing results in abrupt Sept ice decrease
- Extent decreases from 80 to 20% coverage in 10 years.

Simulation of Future Climate

Observations
Simulated
5-year running mean
Simulating Human Land Cover Change in Global Climate Models

Future Directions

- Combine the urban and other land cover datasets at 1 km resolution – use multiple satellite derived sources
- Develop transient datasets compatible with the present Day MODIS derived dataset based on past population and other country level statistics
- Develop a soil degradation model and accompanying datasets
- Develop fire model based on land cover and other national level statistics
Figure 3.4. (a) Annual anomalies of global SST (HadSST2, red lines and blue solid curves), 1650 to 2005, and global SSHA (HadSSH, green curve), 1650 to 2005, relative to the 1961 to 1990 means (°C) from the UK Meteorological Office (UKMO). Figure et al. (2006). The smooth curves show annual variations (see Appendix 3.4). The dashed black curves show smoothed annual global SST anomalies from the 304° (b) Combined annual global SST anomalies, relative to 1961 to 1980 (°C), from HadSST2 blue line, as in (a). from NOAA (Christy et al., 2005); and blue and from HADISST2 (Lamb et al., 2005; green line). The latter two series begin in the 19th century than HadSST2. (c,d) As in (a) but for the Northern Hemisphere only. The SSH anomalies are.

Figure 3.1. Annual anomalies of global land-surface air temperature (°C), 1650 to 2005, relative to the 1961 to 1990 means (°C) from CRUTEM3 updated from Hulme et al. (2002). The smooth curves show annual variations (see Appendix 3.4). The black curve from CRUTEM3 is compared with those from NOAA (Smith and Reynolds, 2003; blue), GISS (Hansen et al., 2001; red) and Lupa et al. (2005; green).
Figure 3.12. Time series for 1900 to 2005 of annual global land precipitation anomalies (mm) from GHCN with respect to the 1961-1990 base period. The smooth curves show decadal variations (see Appendix A) for the GHCN (Peterson and Vose, 1997), PRCC (Chen et al., 2002), GCPP (Adler et al., 2003), GPCP (Rudolf et al., 1994) and CRU (Mitchell and Jones, 2005) data sets.