



Co-funded by the  
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# Urbani toplotni otoci

Termin "toplotni otok" odnosi se na temperature urbanog zraka i površina koje su više od okolnih ruralnih zona.



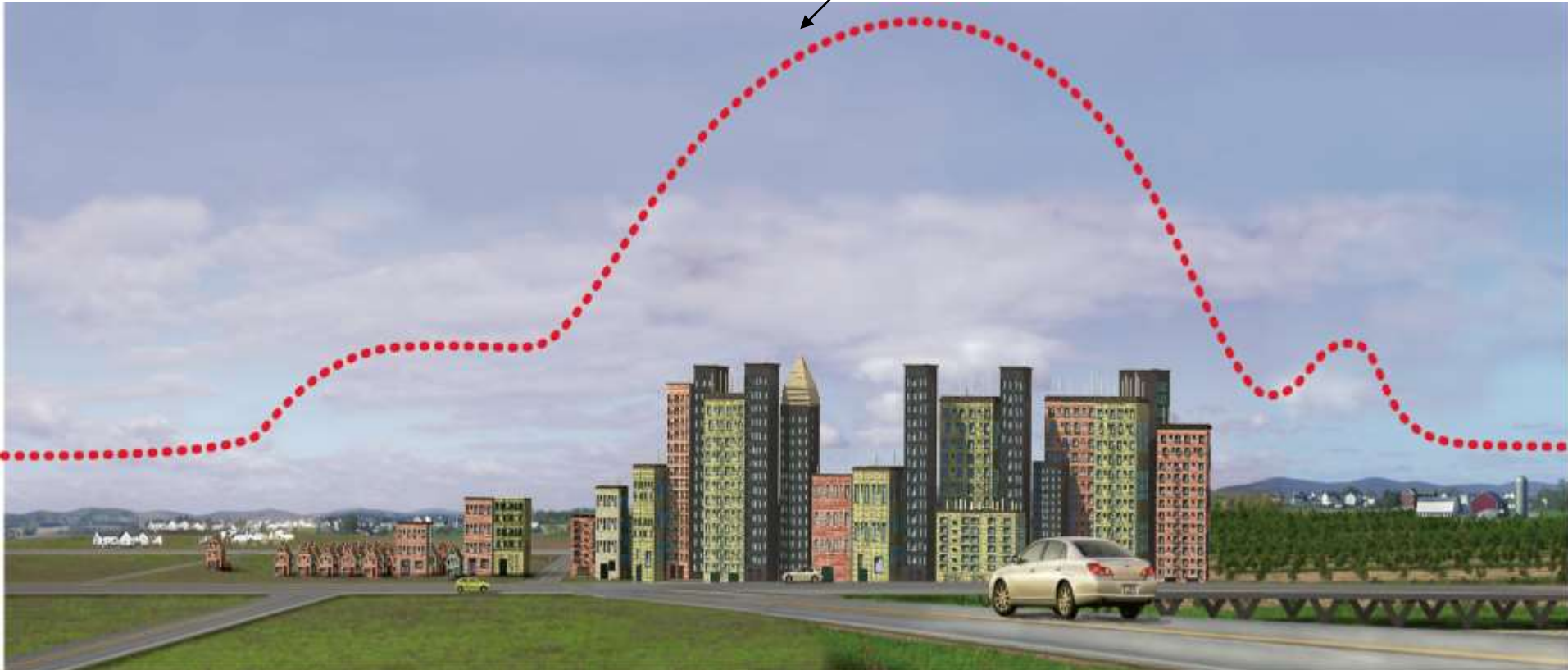


SF, 2008





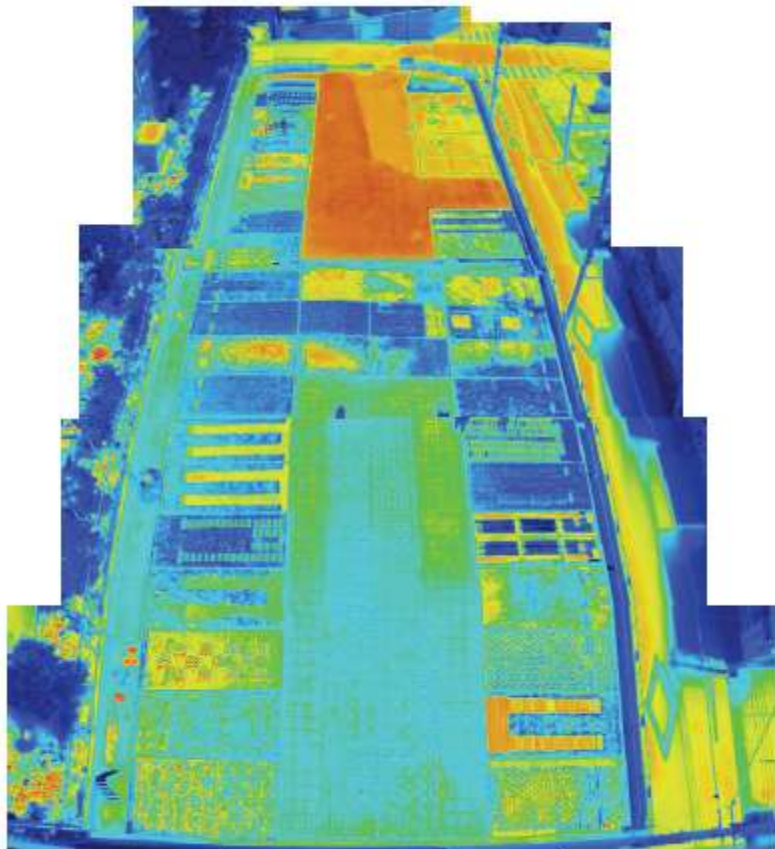
Površinska temperature



**Efekat urbanog toplotnog otoka (UTO):**

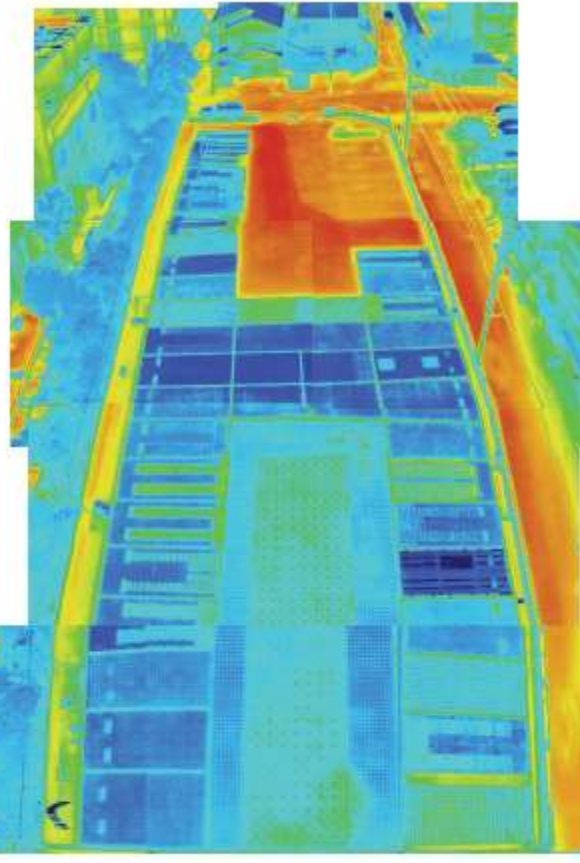
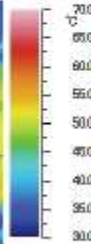
Urbana površina je toplija od okolnih ne urbanih regiona

Potrebno je shvatiti šta su to UTO efekti



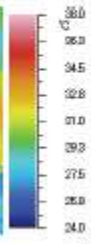
12:00 sati

Max: 70°C



21:00 sati

Max: 38°C

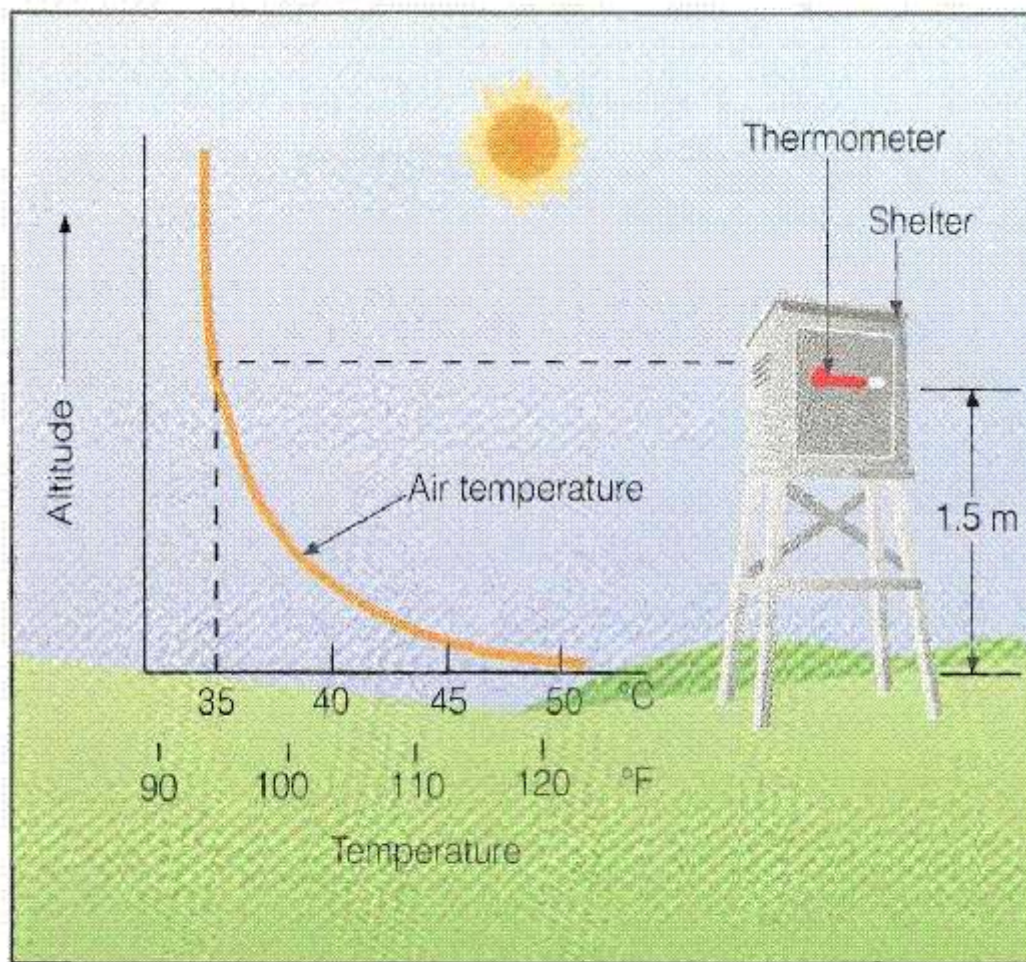


Min: 24°C

**Eksperiment na parkingu**



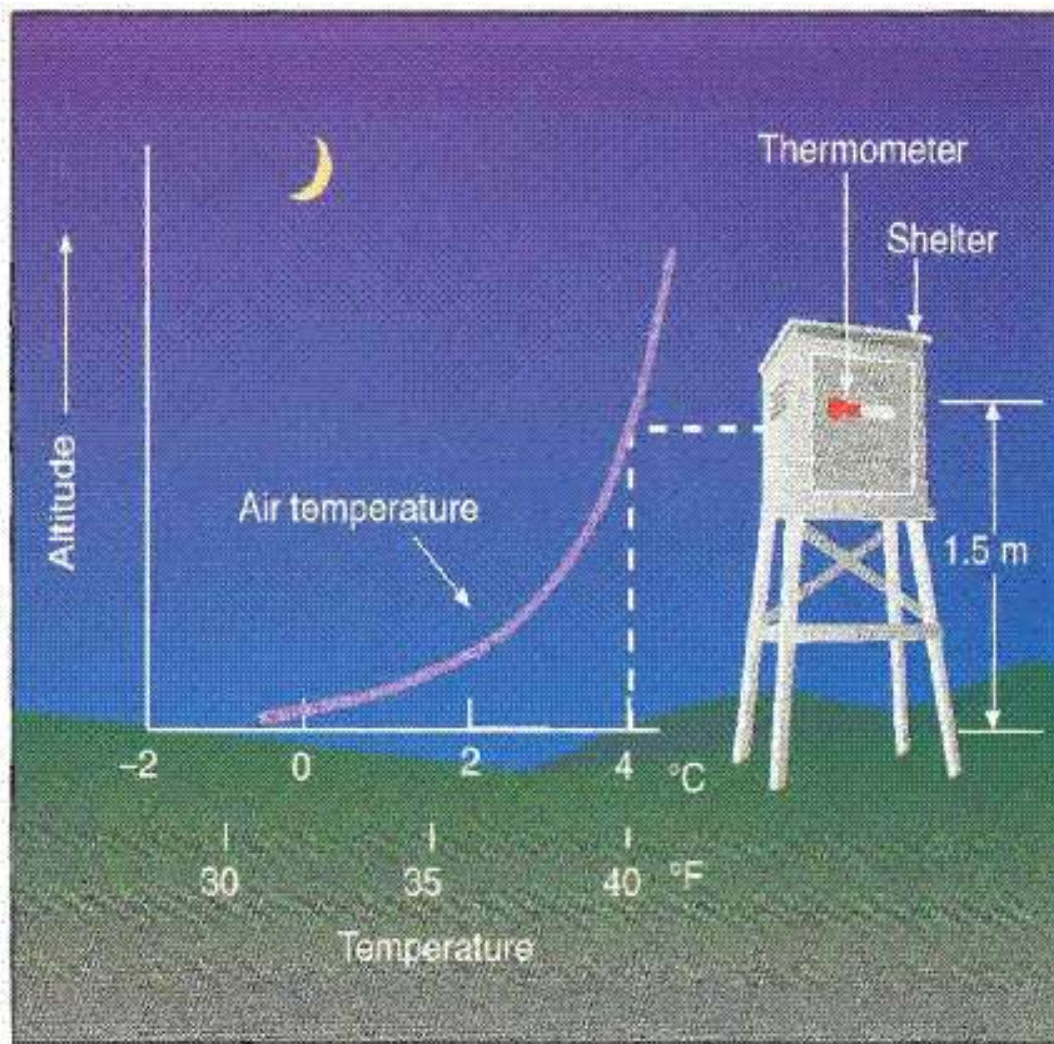
## Kako se mjeri temperatura površine



**FIGURE 3.12**

*On a sunny, calm day, the air near the surface can be substantially warmer than the air a meter or so above the surface.*

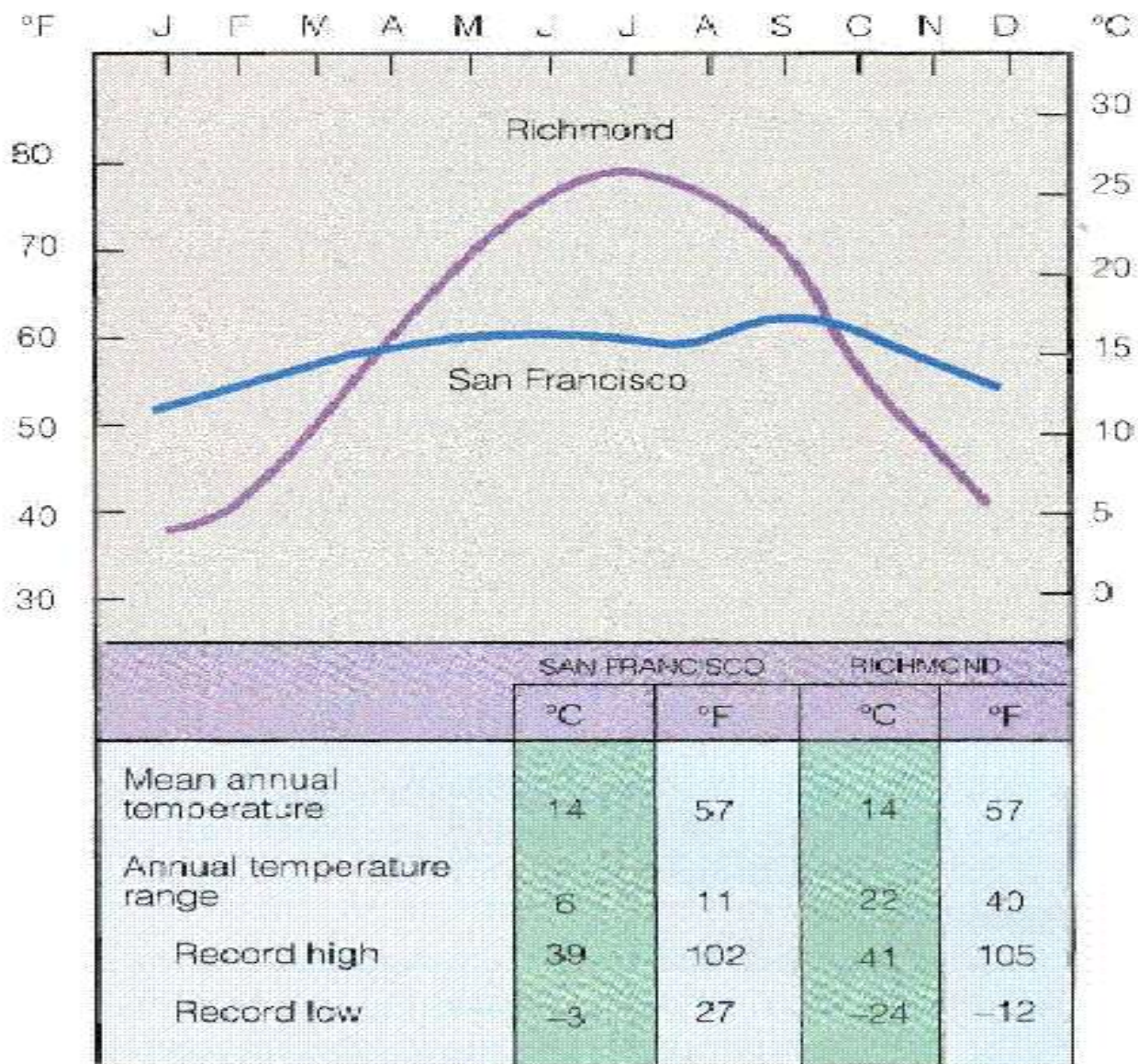




**FIGURE 3.15**

*On a clear, calm night, the air near the surface can be much colder than the air above. The increase in air temperature with increasing height above the surface is called a radiation temperature inversion.*





**FIGURE 3.24**

*Temperature data for San Francisco, California (37°N) and Richmond, Virginia (37°N)—two cities with the same mean annual temperature.*



# Video: Efekat Urbanog toplotnog otoka (UTO)

[Urban Heat Island.mp4](#)

- razlozi za UTO
- kako reducirati UTO

# Video: Efekat urbanih padavina

[Urban Rainfall Effect.mp4](#)



# Video

- Uočeni efekti na urbane sisteme

[Animacija tornada u Atlanti](#)

# Zbog čega je potrebno proučavati urbane regione?

- Urbani regioni su **ekstremni slučaj** antropogenih promjena prirodnog pokrivača
- Urbani regioni se odlikuju snažnim zagađenjem, emisijom gasova staklenika.
- 60% ljudi u SAD živi u gradovima
- Urbani regioni imaju jedinstvene cikluse vode i toplote što direktno utiče na živote ljudi



# Značajne publikacije

**Jin, M.**, 2012; Development of UHI index. *J. of Climate*

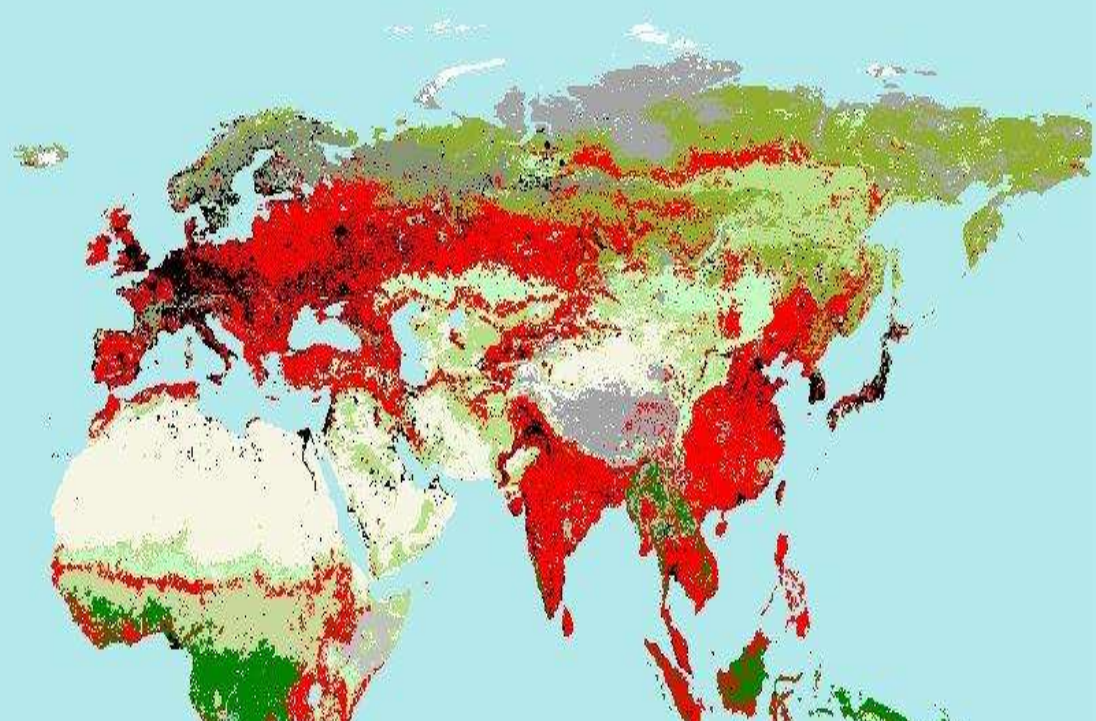
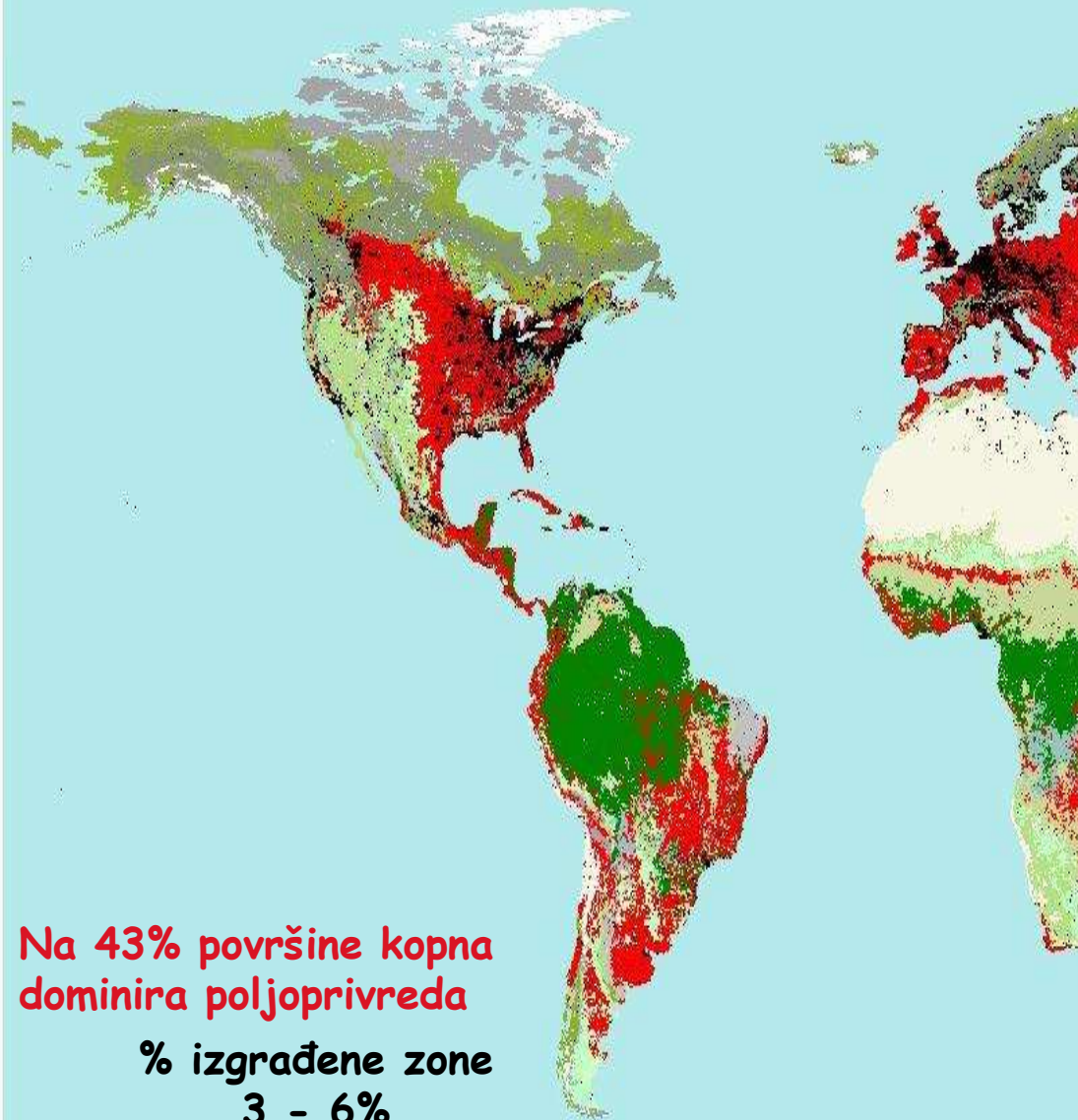
**Jin, M.**, J. M. Shepherd, M. D. King, 2005: Urban aerosols and their interaction with clouds and rainfall: A case study for New York and Houston. *J. Geophysical Research*, 110, D10S20, doi:10.1029/2004JD005081.

**Jin, M.**, R. E. Dickinson, and D-L. Zhang, 2005: The footprint of urban areas on global climate as characterized by MODIS. *Journal of Climate*, vol. 18, No. 10, pages 1551-1565

**Jin, M.** and J. M. Shepherd, 2005: On including urban landscape in land surface model – How can satellite data help? *Bull. AMS*, vol 86, No. 5, 681-689.

**Jin, M.** J. M. Shepherd, and Christa Peters-Lidard, 2007: Development of A Parameterization For Simulating the Urban Temperature Hazard Using Satellite Observations In Climate Model in press by Natural Hazards.

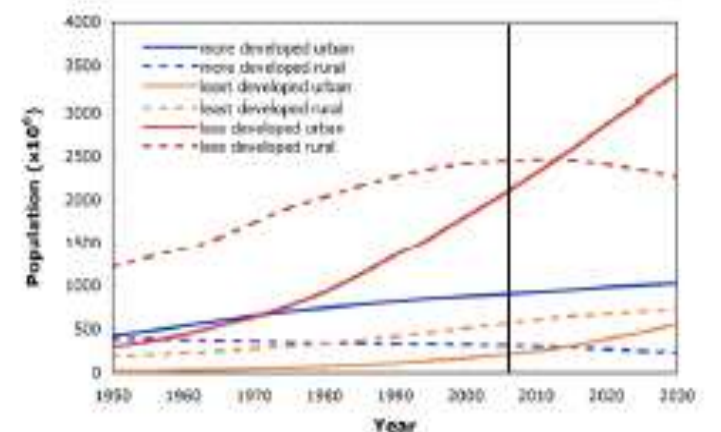
**Jin, M.** and M. J. Shepherd, 2007: Aerosol effects on clouds and rainfall: urban vs. ocean. Revised for JGR



Na 43% površine kopna  
dominira poljoprivreda

% izgrađene zone  
3 - 6%

Urban and rural population, 1950-2030

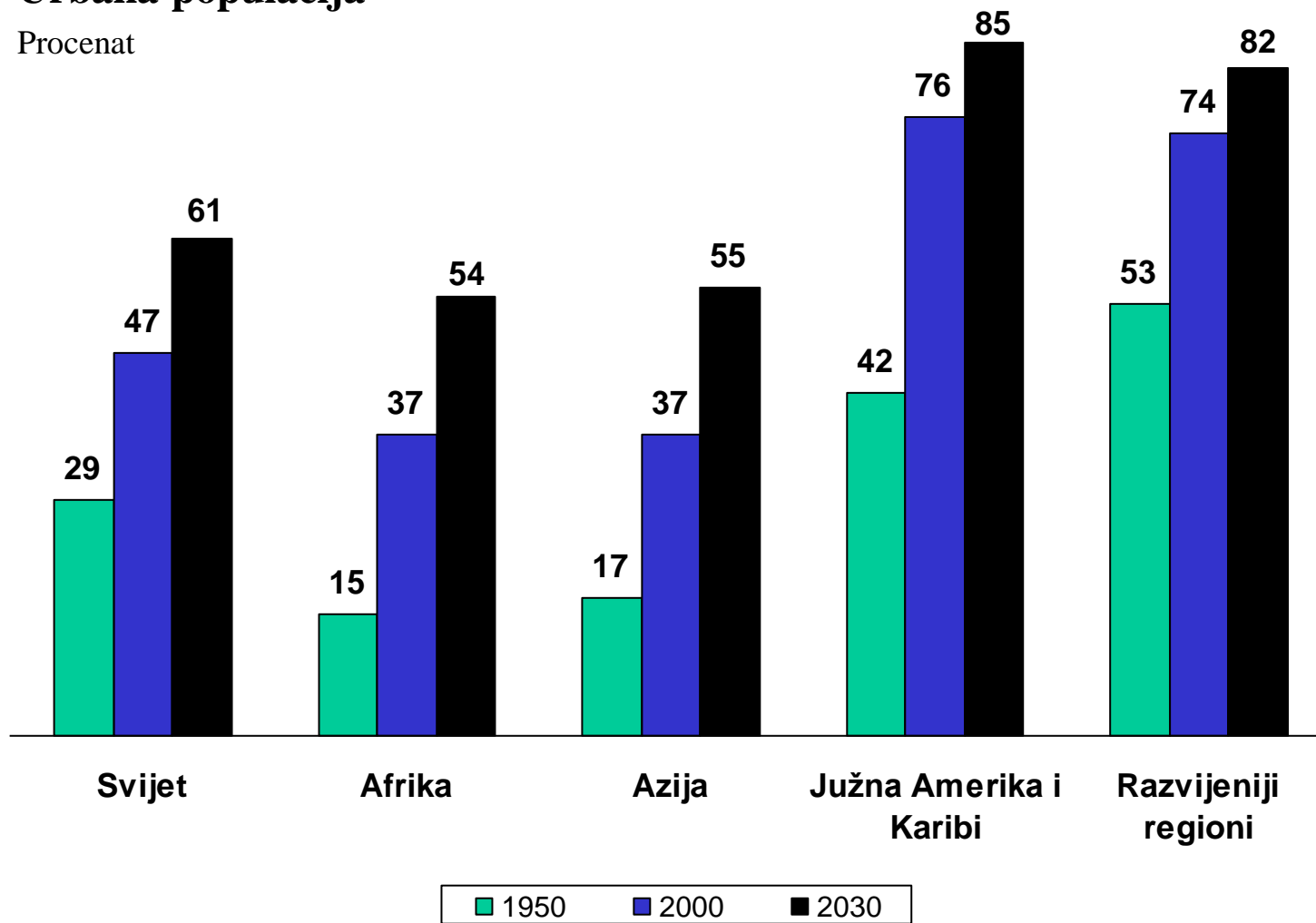




# Trendovi u urbanizaciji, regionalno

## Urbana populacija

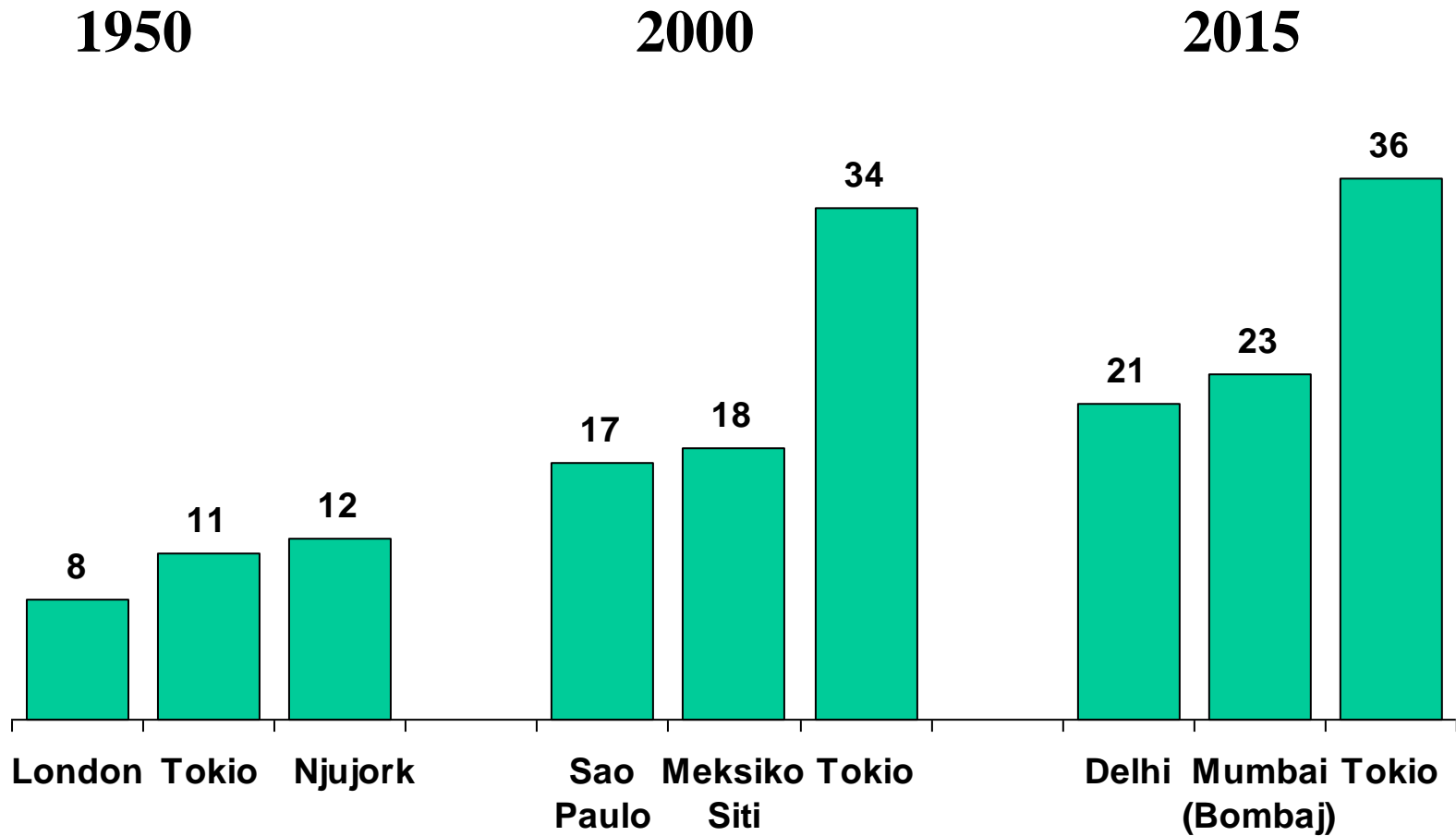
Procenat



Izvor: United Nations, *World Urbanization Prospects: The 2003 Revision* (medium scenario), 2004.

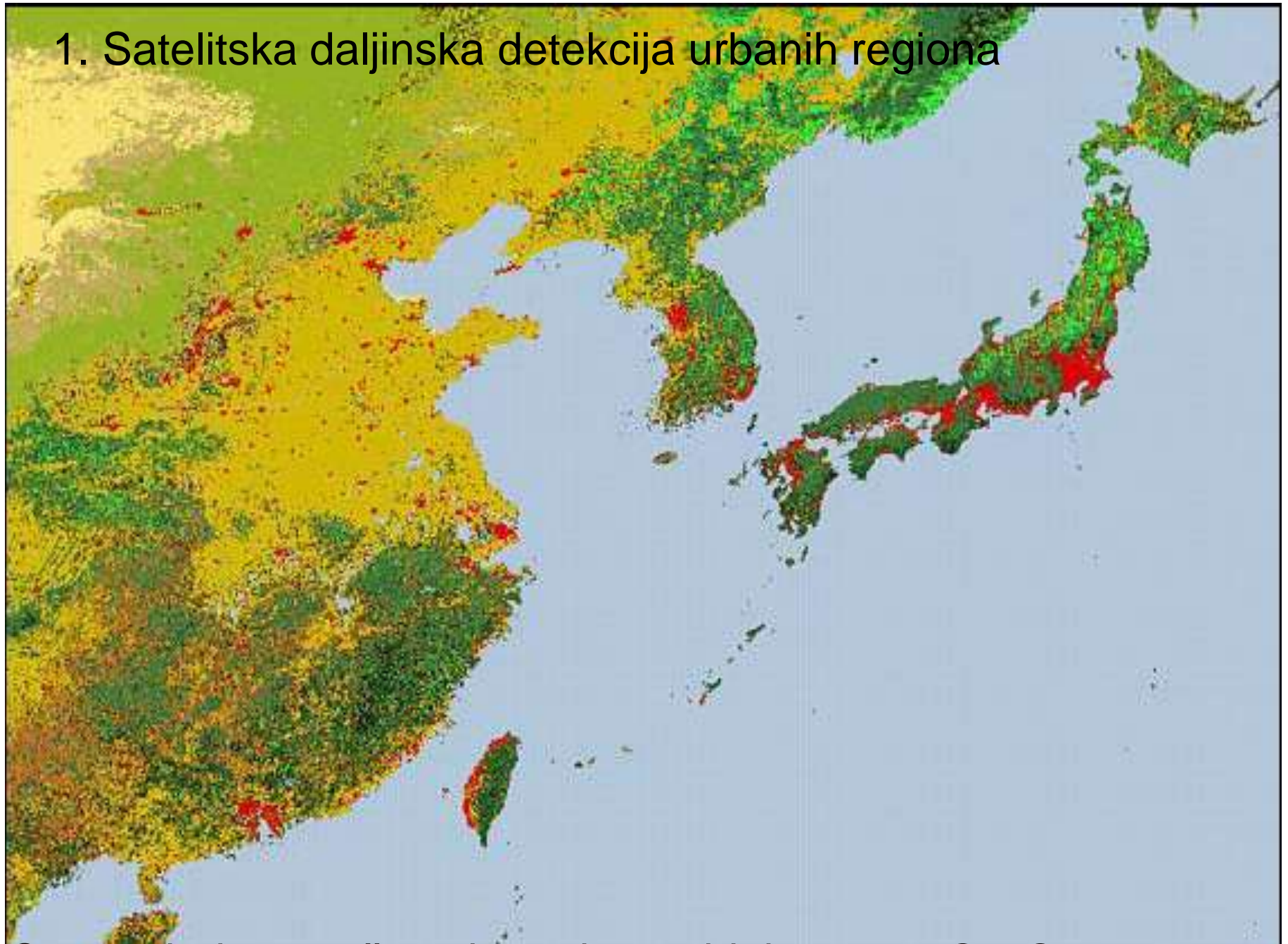
# Najveći gradovi, globalno

Milioni



Izvor: United Nations, *World Urbanization Prospects: The 2003 Revision* (medium scenario), 2004.

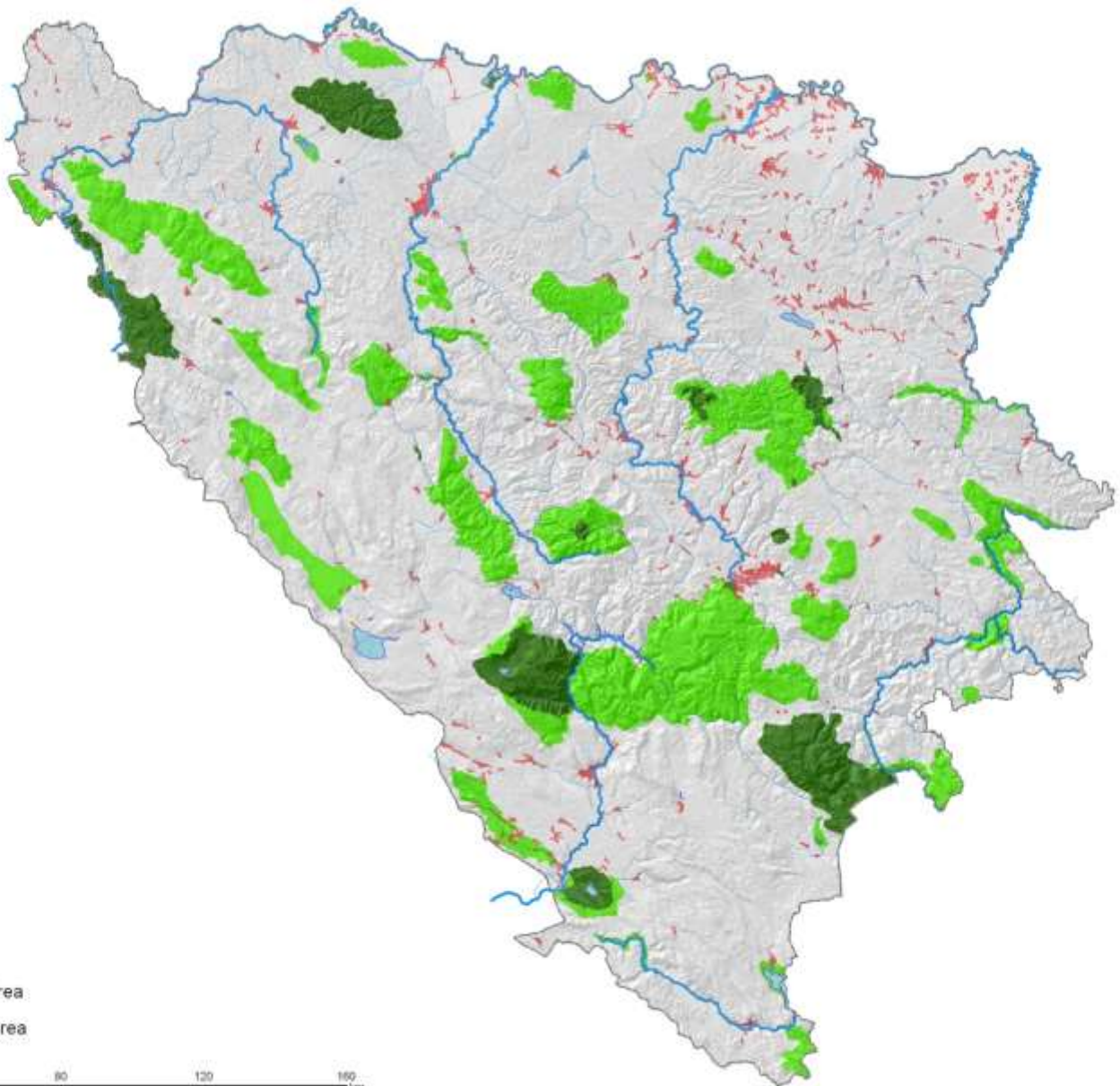
# 1. Satelitska daljinska detekcija urbanih regiona



Crvena boja označava izgrađene objekte



MODIS land cover





-  State border
-  river
-  river

**Legend:**

-  Existing protected area
-  Planned protected area

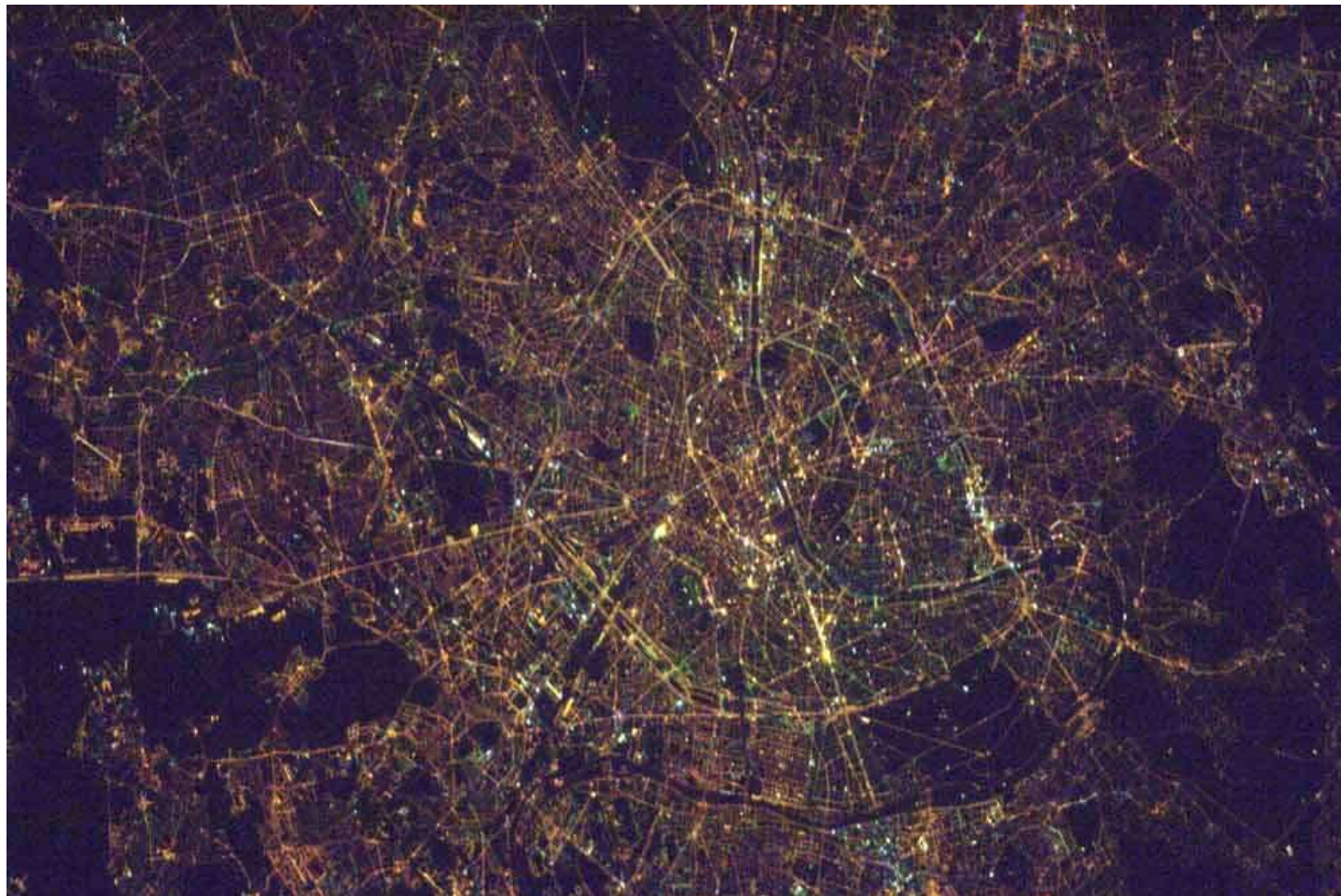


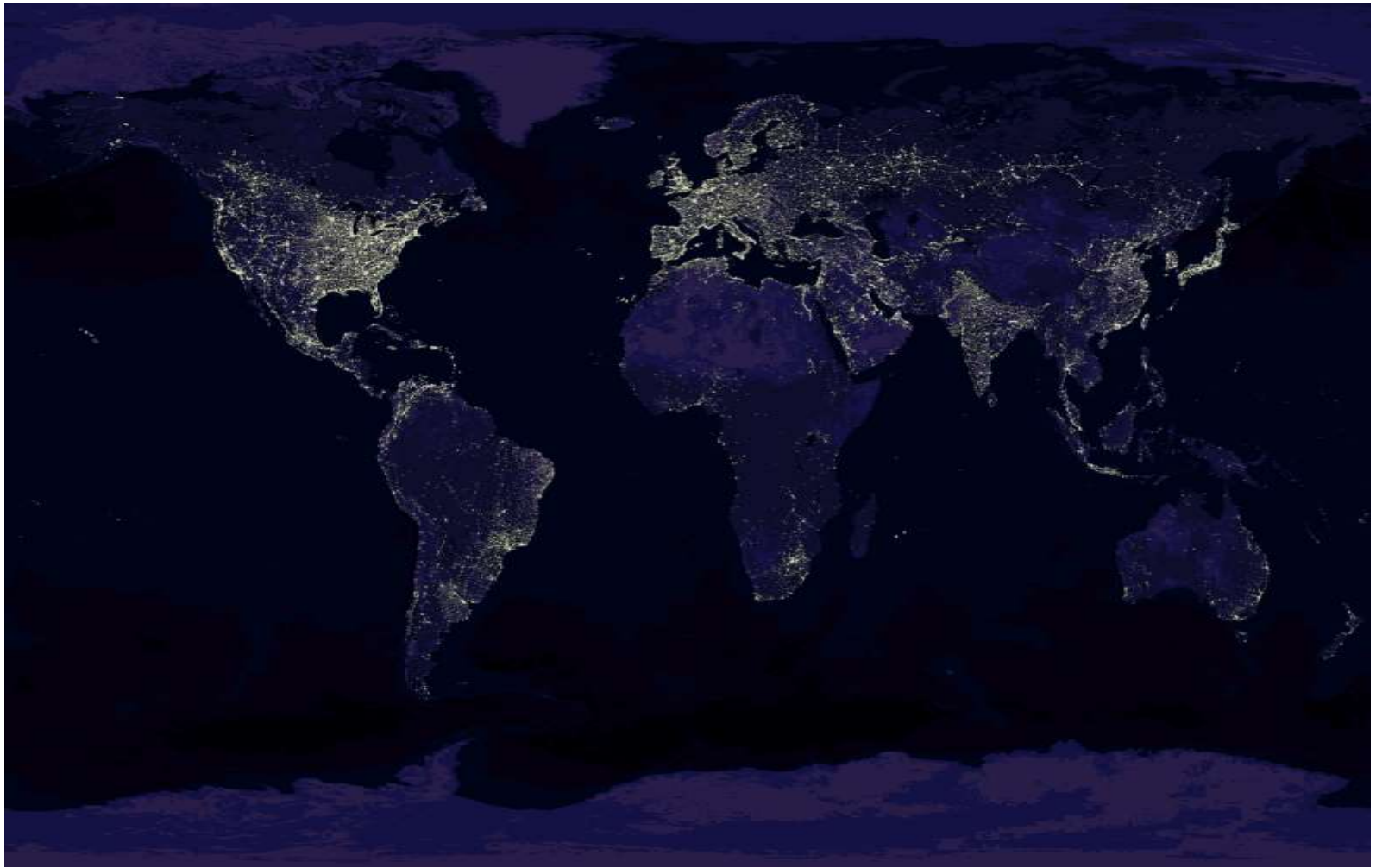
# Noćna svjetla Tokio





# Noćna svjetla Pariza





Izvor: U.S. Defense Meteorological Satellites Program (DMSP)





Satelitska posmatranja urbanih sistema:

**Svojstva kopnene površine:**

površinska temperature, površinski albedo, radijacija, vlaga tla, vegetacijski pokrov

**Atmosferski uvjeti:** aerosol,  
oblaci i kiša

Ovo ukazuje da



**Urbanizacija značajno mijenja vrijeme i klimu**

# Efekat urbanog toplotnog otoka (UTO)

Ovaj fenomen objašnjava urbane i suburbane temperature koje su **1 do 6°C** više nego kod okolnih ruralnih zona.

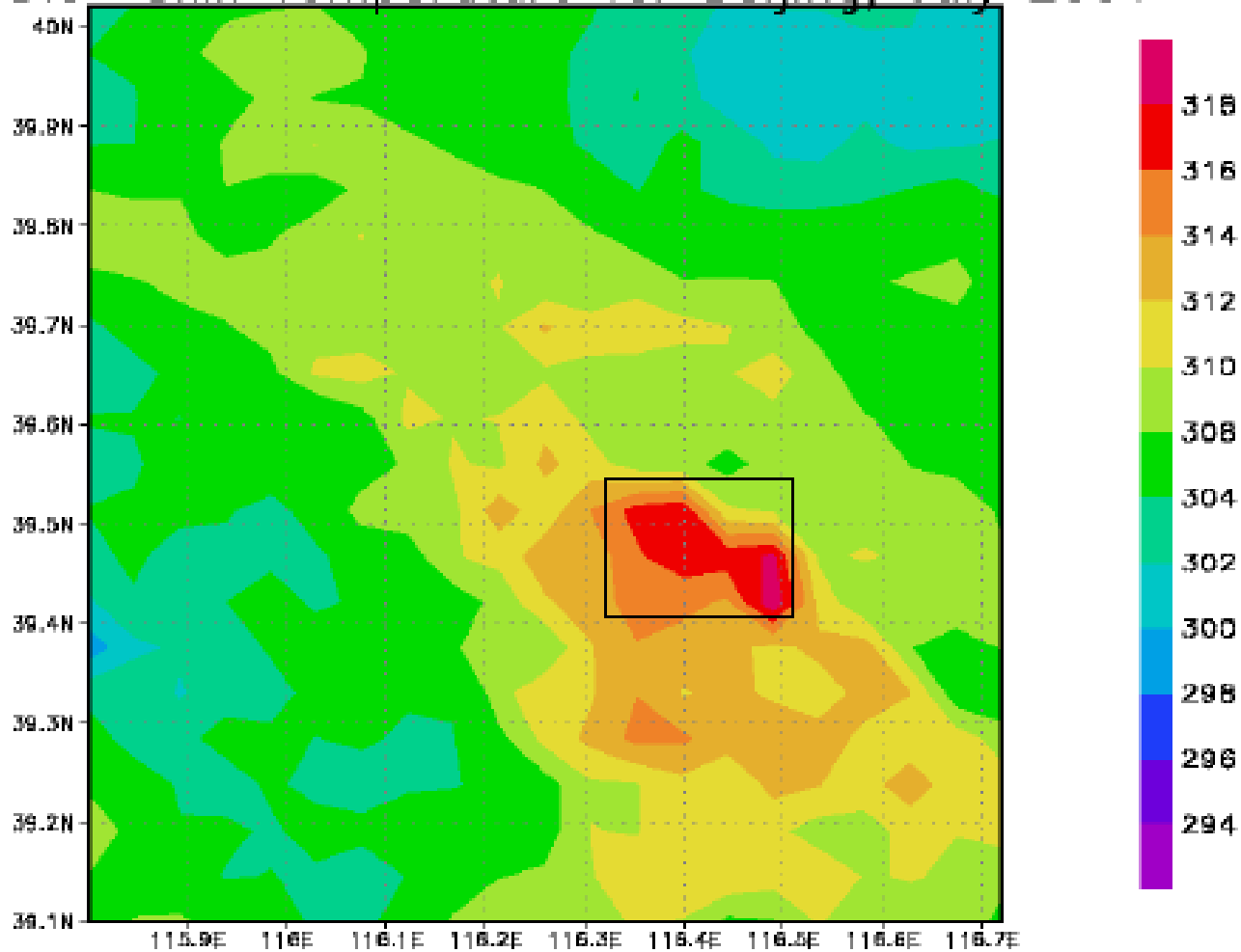
## UTO uticaji:

Povišene temperature mogu uticati na zajednice povećanjem energetske potrebe, troškova korištenja klima uređaja, nivoa zagađenja zraka, i oboljenja povezanih sa toplotom. Visoka temperatura takođe pospješuje površinsku konvekciju, i uzrokuje više oblaka i padavina.



# Uticaj urbanizacije na temperaturu površine

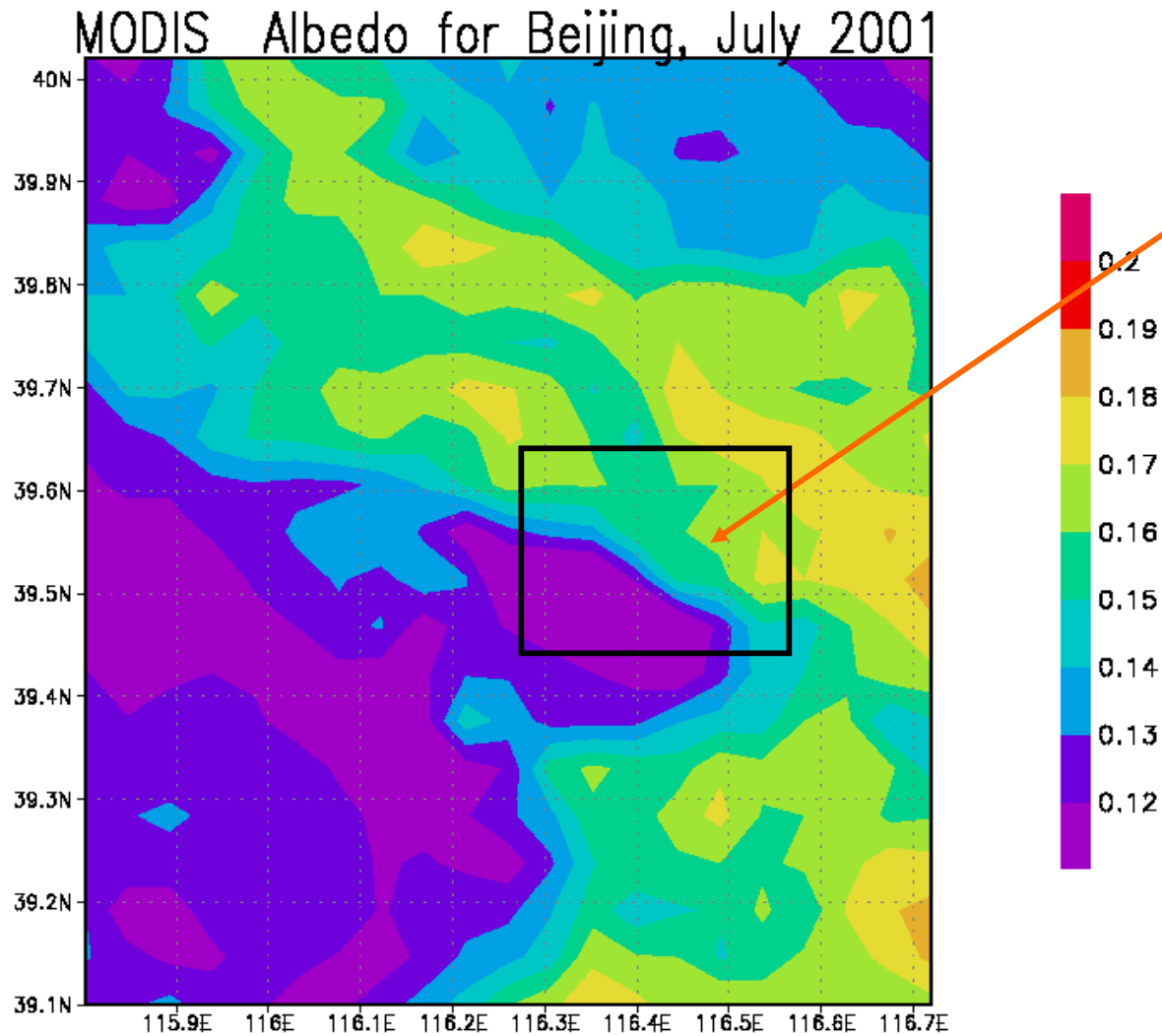
MODIS Skin Temperature for Beijing, July 2001



10°C !!!

EOS MODIS je zabilježio da mjesečna srednja dnevna temperatura ispoljava evidentan efekat urbanog toplotnog otoka (Copied from Jin et al, 2005a). Crvena zona predstavlja regione sa gustim zgradama u Pekingu.

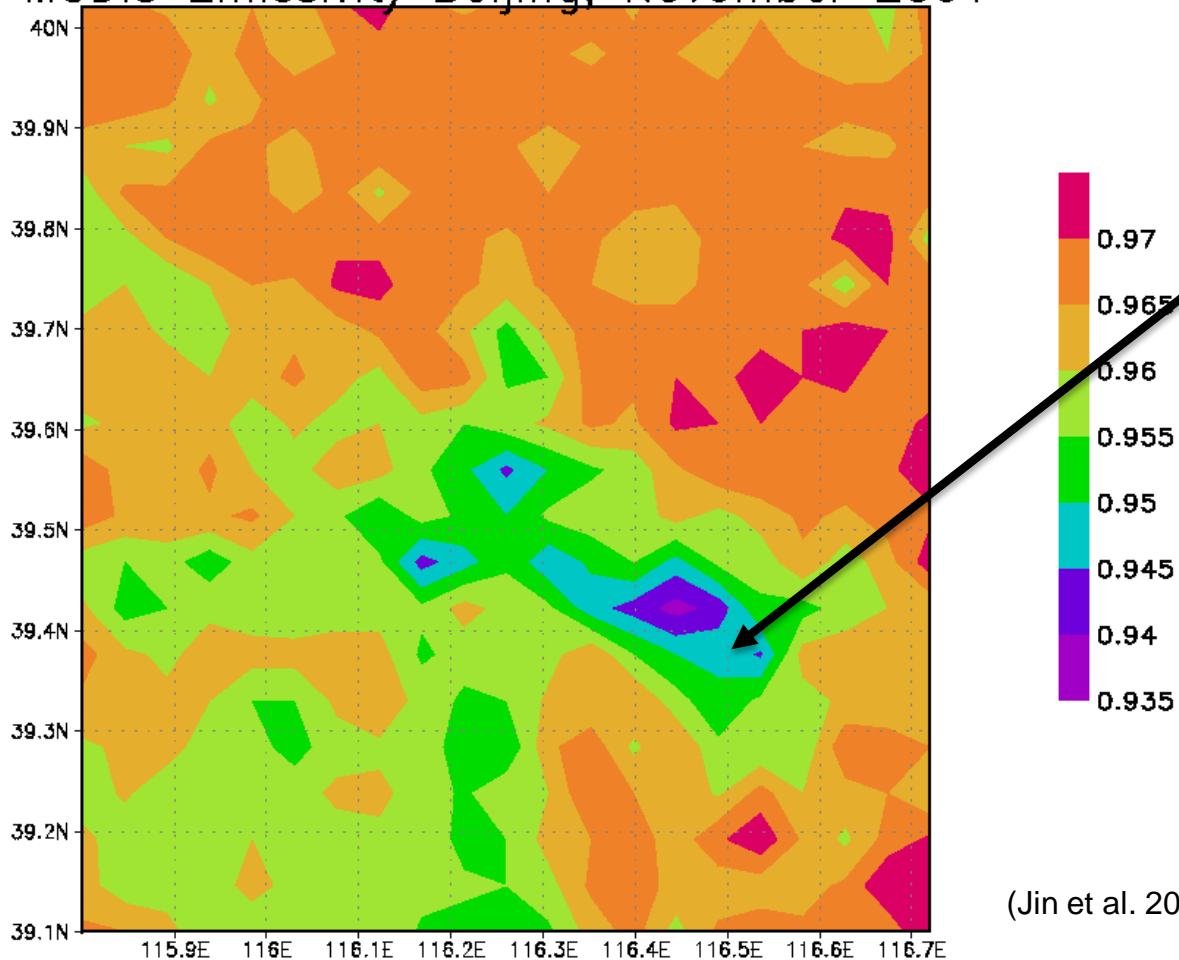
# Urbanizacija mijenja albedo površine (MODIS)



Albedo urbane površine ima 4-6% pad ->  
Više solarne radijacije će biti apsorbavano na površini →  
Porast površinske temperature

# Urbanizacija reducira emisivnost površine (MODIS)

MODIS Emissivity Beijing, November 2001



(Jin et al. 2005, J. of Climate)

Urbana zona reducira površinsku emisivnost ->  
Manje dugotalasne radijacije se emitira sa površine →  
Više toplote se zadržava na površini →  
Raste površinska temperatura



# Šta se može uraditi ?

Da se smanji negativni efekat UTO ?

**Edukacija** : ključni koncept većine redukcijskih nastojanja

**Hladni krovovi**: preko 90% krovova u SAD su tamne boje. Ove nisko reflektivne površine dostižu temperature od 66 do 88°C)

**Stabla i vegetacija**

**Hladni pločnici**

# Hladni krovovi

Sistemi hladnih krovova sa visokom refleksijom i emisijom ostaju i do 39°C hladniji od tradicionalnih materijala za vrijeme najtoplijih ljetnih dana.



The Utah Olympic Oval koristi tehnologiju hladnih krovova

# Šta je "Hladni krov"?

Materijali za hladni krov ima dva značajna svojstva površine:

- Visoka solarna refleksija – ili albedo
- Visoka termalna emisija

Solarna refleksija je procenat solarne energije koju reflektira određena površina.

Termalna emisija se definiše kao procenat energije koju materijal može zračiti nakon što je apsorbuje.



### 3. Urbani aerosoli i njihovi direktni efekti na Oblake, insolaciju površine, i temperaturu površine



# Video

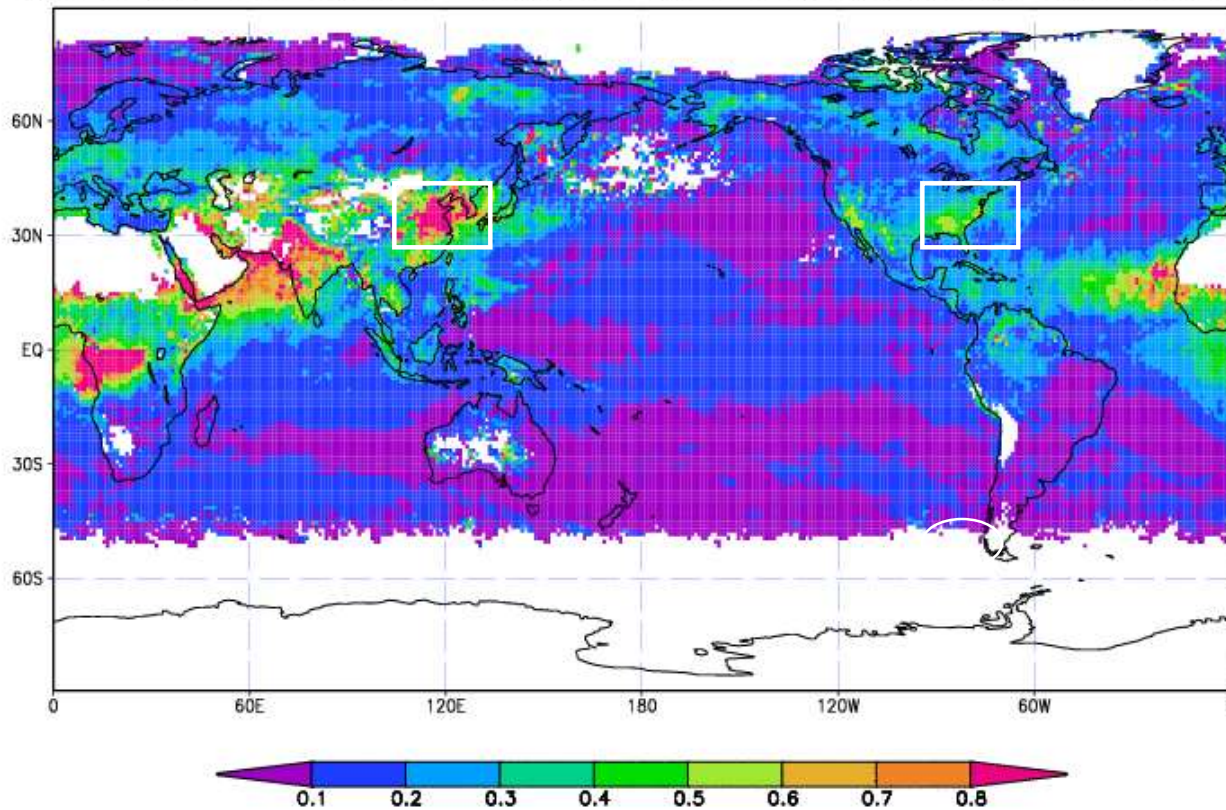
Efekat urbanog aerosola na padavine

[Summer Precip w-Pollution.mp4](#)

[Winter Precip w-Pollution.mp4](#)

# NASA MODIS zabilježena distribucija aerosol

MODIS Aerosol Optical Thickness at 0.55micrometer, July 2005



Juli 2005



# Izvori zagađenja u atmosferi urbanih zona

Saobraćaj



Aerosoli su čvrste/tečne čestice u atmosferi

Veličina -0.01-100 $\mu$ m

Industrija



Vrijeme zadržavanja – sati-dani

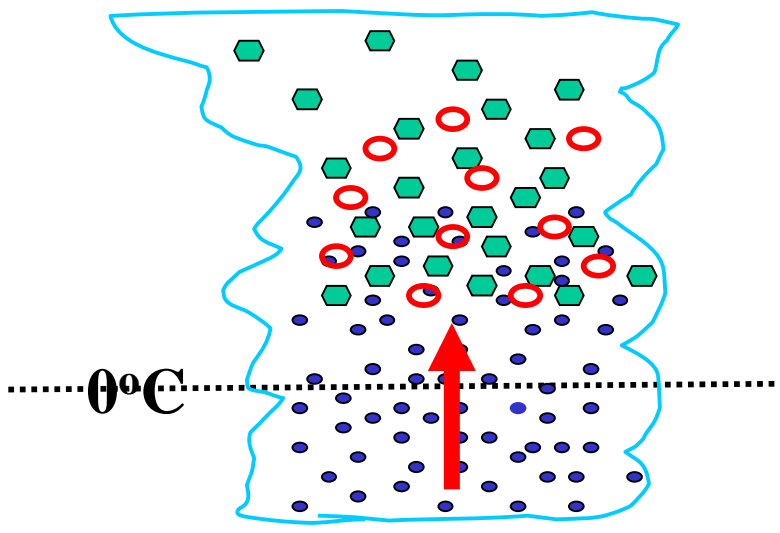
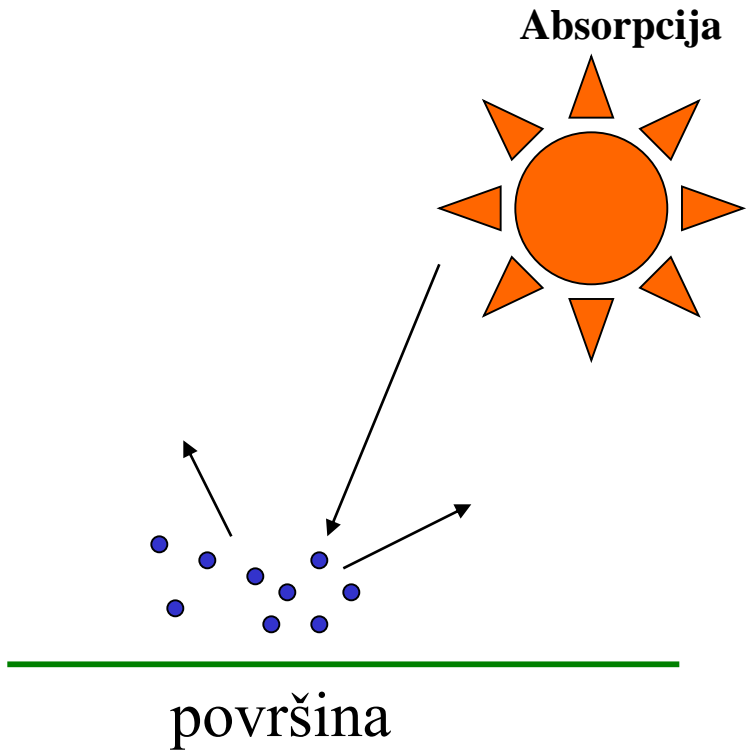
Zagrijavanje stanova



The use of energy efficient design means that this can avoid  
exposure to indoor air quality problems.  
Source: WHO Environmental Health

# Direktni efekat aerosola: Razbacivanje

# Indirektni efekti: služe kao CCN



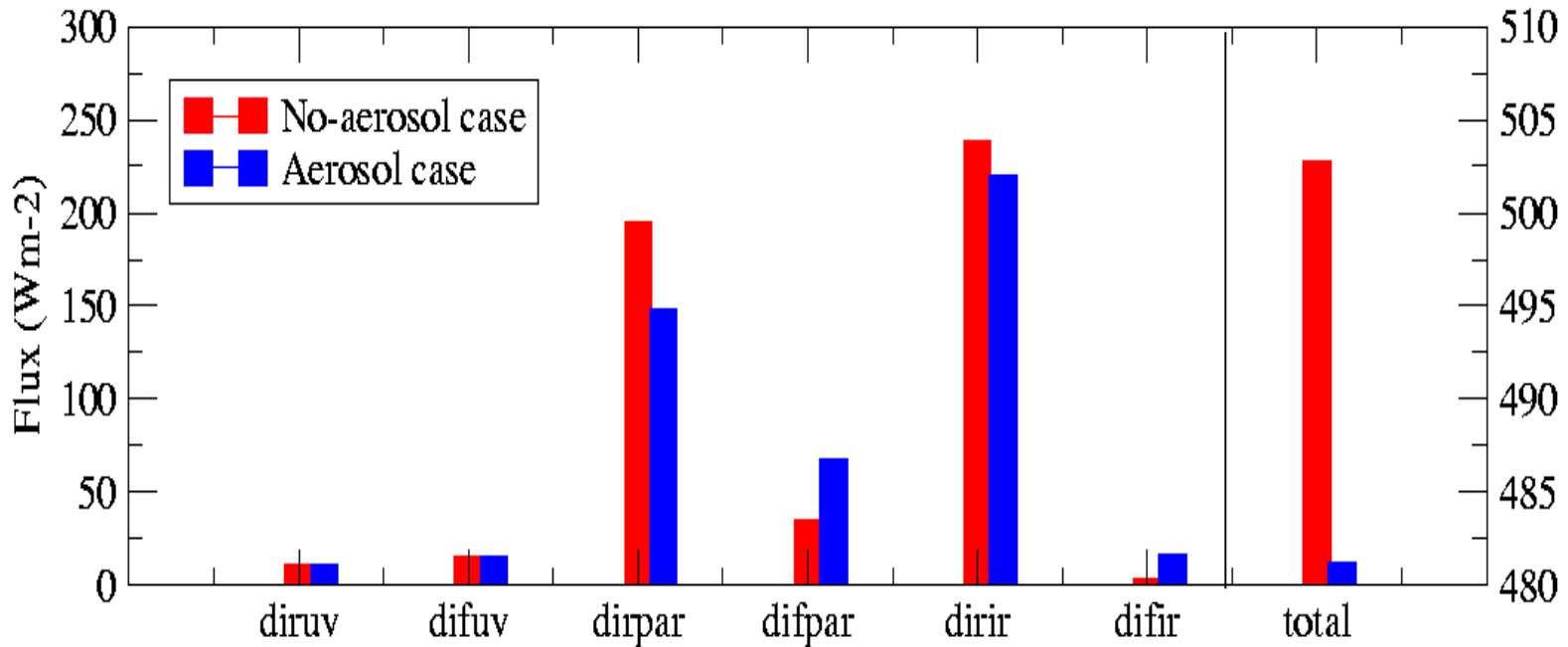
- Kapljice oblaka
- Kapi kiše
- ⬠ Krsitali leda
- Ledene padavine

Crni ugljik zagrijava atmosferu i površinu  
 Većina aerosola hladi površinu

Više aerosola -> mali efektivni radius oblaka ->  
 Visoki albedo oblaka -> hlađenje (Kaufmann and Koren 2006)

Više aerosola -> reducirane padavine (Rosenfeld 2000)

# Aerosol smanjuje površinsku insolaciju



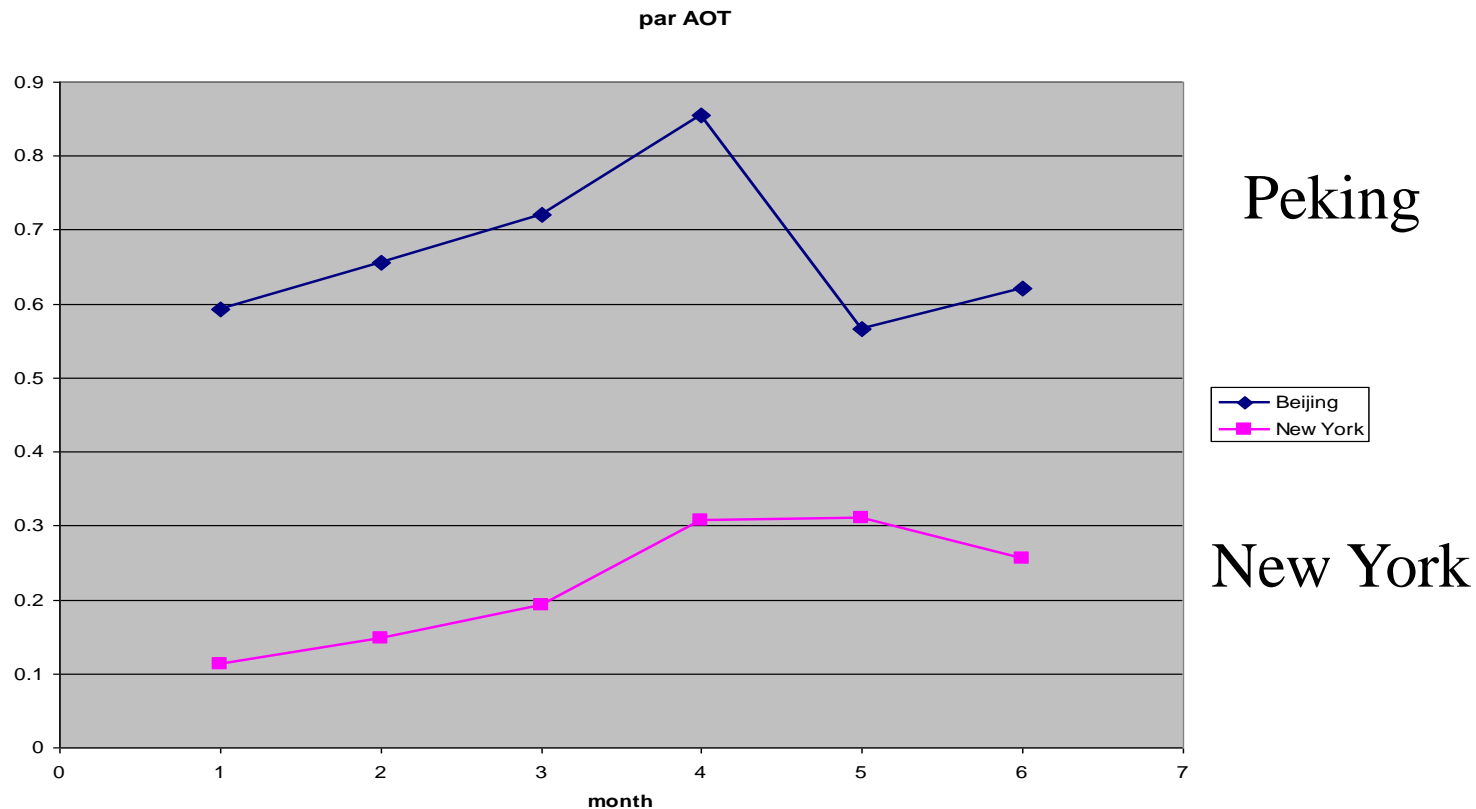
Totalna solarna radijacija smanjena aerosolom = **20Wm<sup>-2</sup>**

*Zasnovano na NASA GMAO radiativnom transfer modelu*

(Jin, Shepherd, and King, 2005, JGR)



## 6-godišnji prosjek AERONET mjerenja

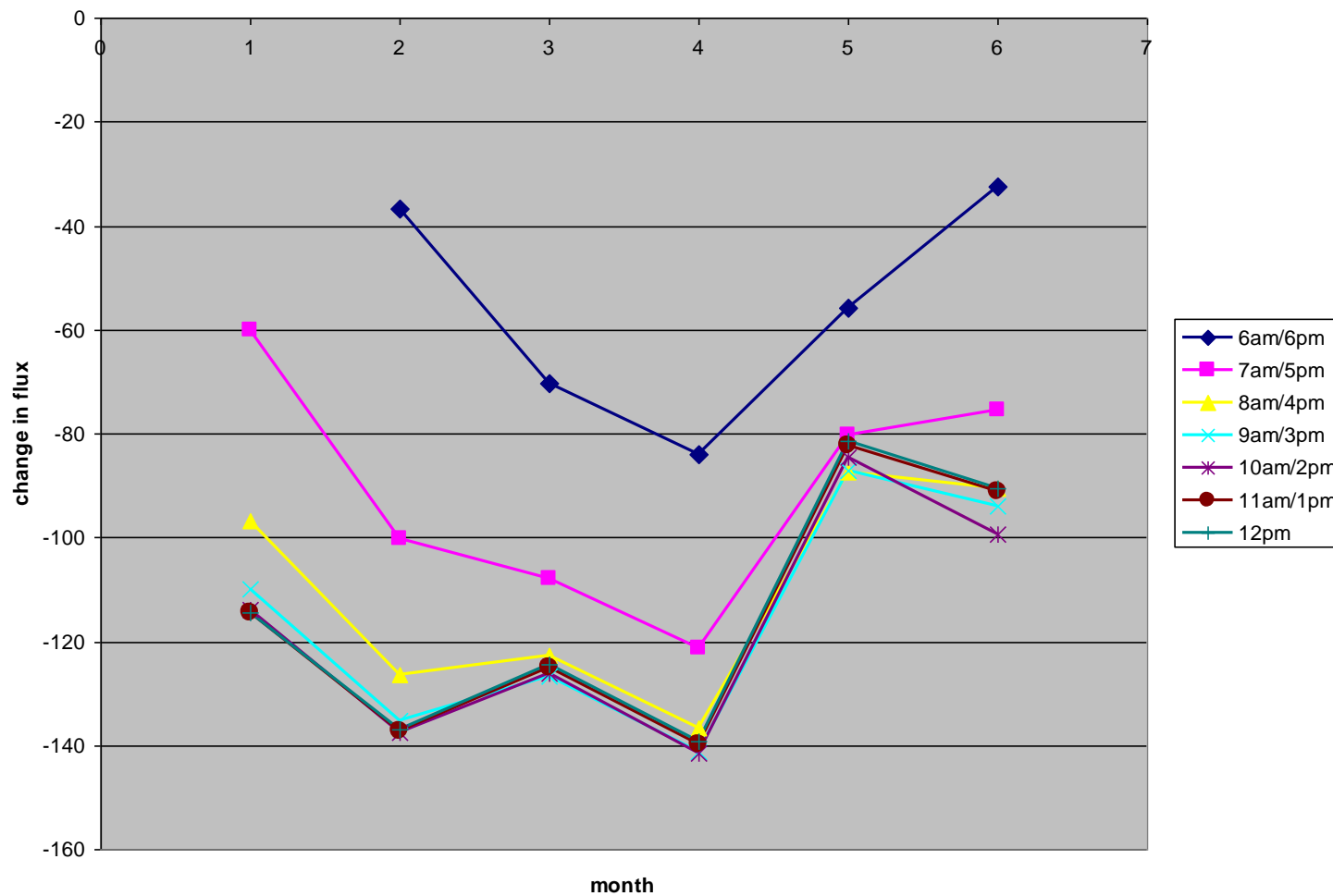


6-godišnja dnevna prosječna optička debljina pokazuje

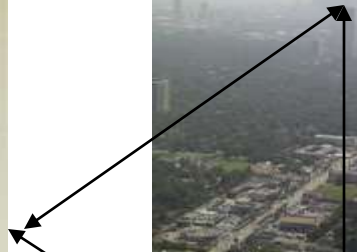
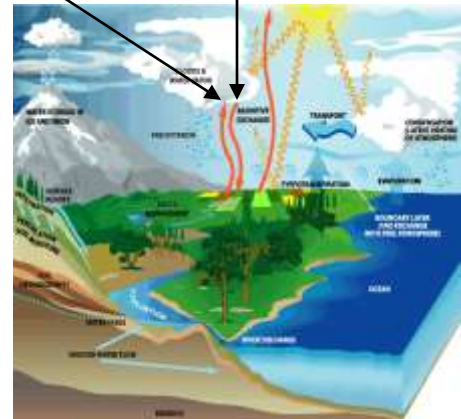
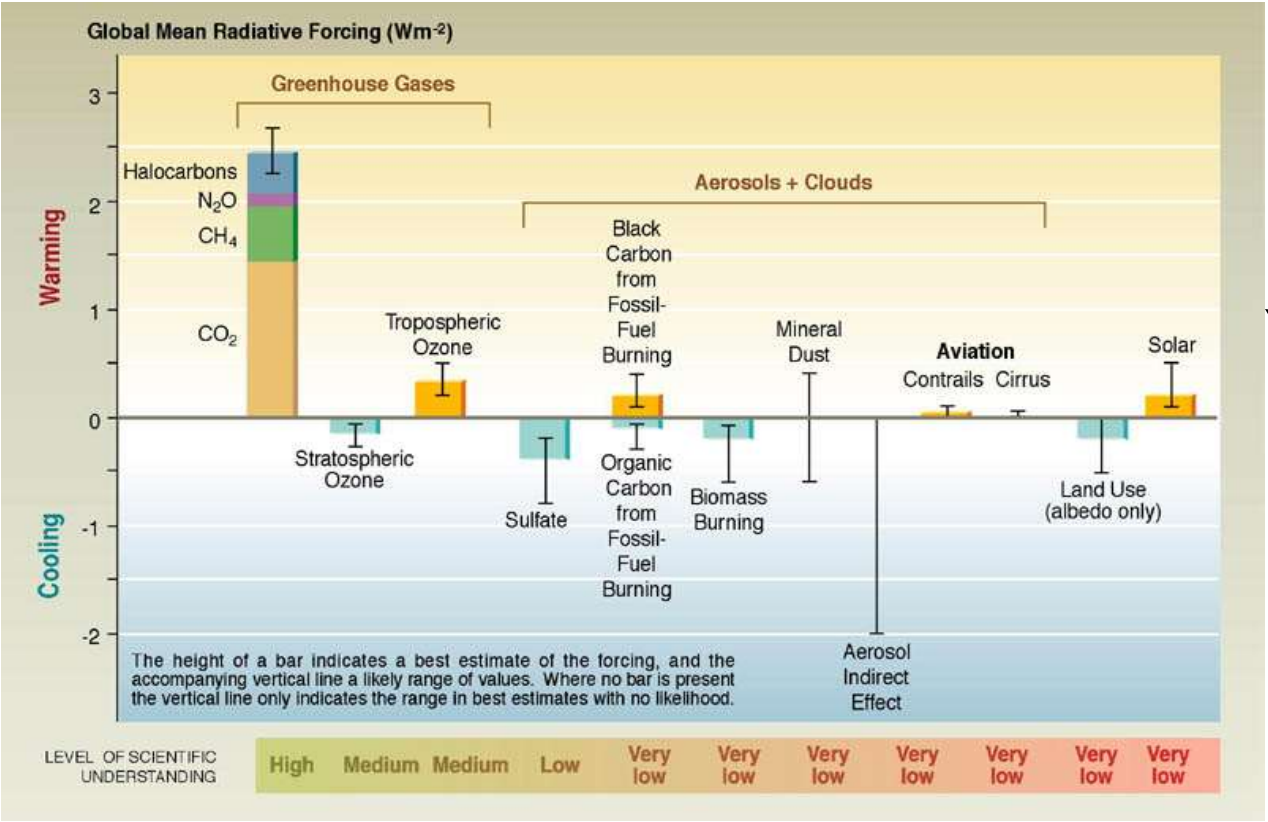
- Značajne razlike između Pekinga i New Yorka
- Sezonsku varijaciju u urbanom aerosolu

# Redukcija površinske insolacije, Peking

Beijing Ftotal



Urbani efekti na zralenje toplote su poznati, ali efekti na procese vodenog ciklusa (npr., variranje padavina) su manje istraženi (IPCC, 2007)





Profesor Marshall Shepherd -The University of Georgia zapaža:

**Ljudske aktivnosti u aridnim urbanim sredinama mogu uticati na padavine i ciklus vode**

<http://www.sciencedaily.com/releases/2006/06/060619222554.htm>

**12-14 % porast** (što naučnici nazivaju anomalijom)  
**u padavinama** u SI predgrađima Feniksa od pre-urbanog (1895-1949) do post-urbanog (1950-2003) perioda.



## A Thousand Degrees and Freezing to Death



Is there somewhere in our atmosphere where the air temperature can be exceedingly high (say above  $1000^{\circ}\text{C}$  or  $1800^{\circ}\text{F}$ )

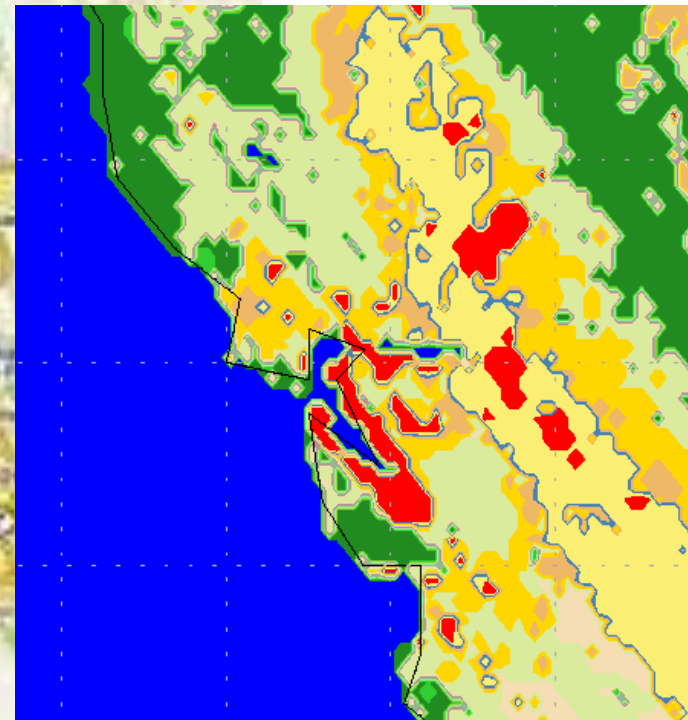
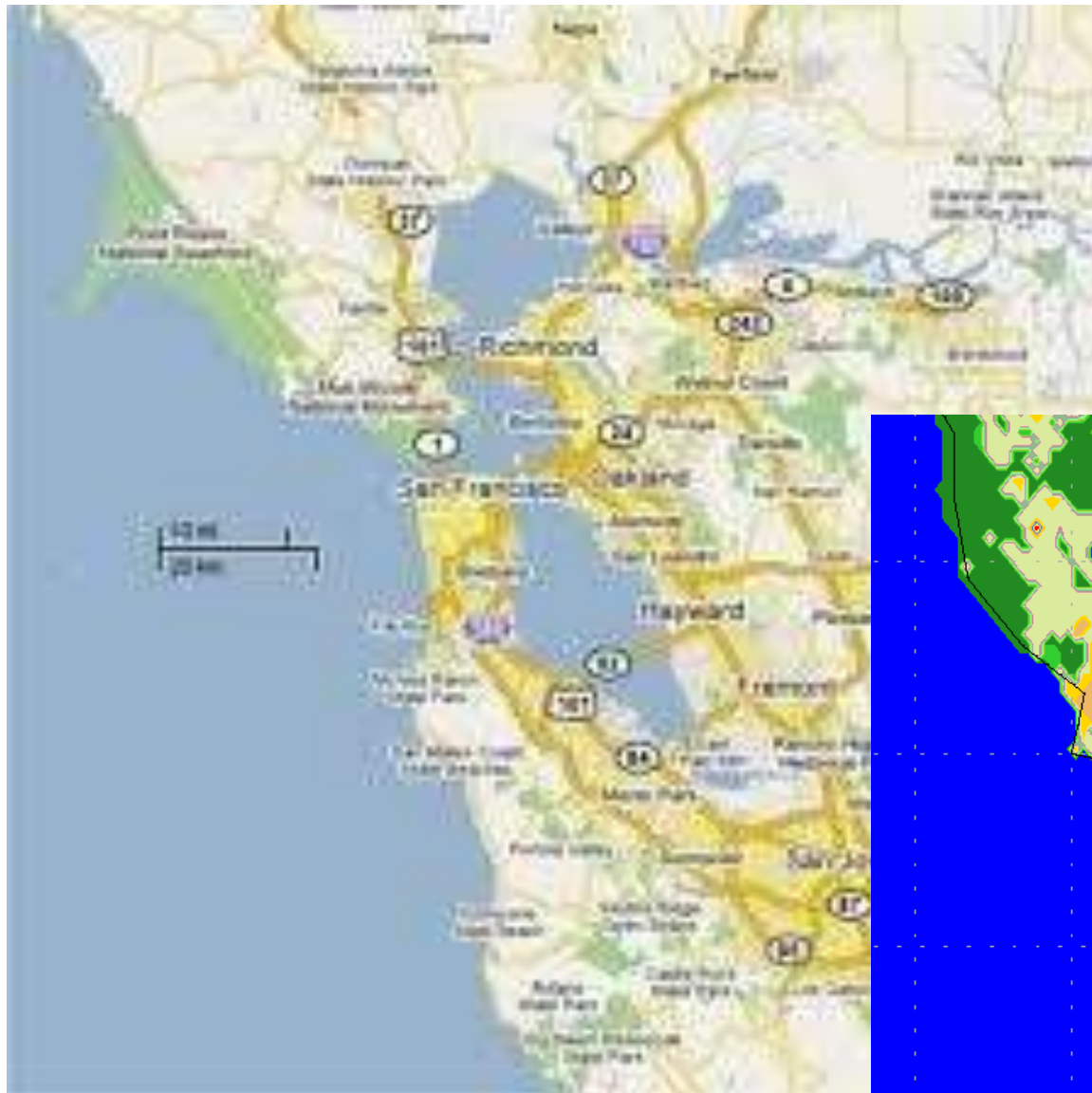
yet a person might feel extremely cold? There is a region, but it's not at the earth's surface.

You may recall from Chapter 1, Fig. 1.9, that in the upper reaches of our atmosphere (in the middle and upper thermosphere), air temperatures may exceed  $1000^{\circ}\text{C}$ . However, a thermometer shielded from the sun in this region of the atmosphere would indicate an extremely low temperature. This apparent discrepancy lies in the meaning of air temperature and how we measure it.

In Chapter 2, we learned that the air temperature is directly related to the average speed at which the air molecules are moving—faster speeds correspond to higher temperatures. In the middle and upper thermosphere, air molecules are zipping about at speeds corresponding to extremely high temperatures. However, in order to transfer enough energy to heat something up by conduction (exposed skin or a thermometer bulb), an extremely large number of molecules must collide with the object. In the “thin” air of the upper atmosphere, air molecules are moving extraordinarily fast, but there are simply not enough of them bouncing against the ther-

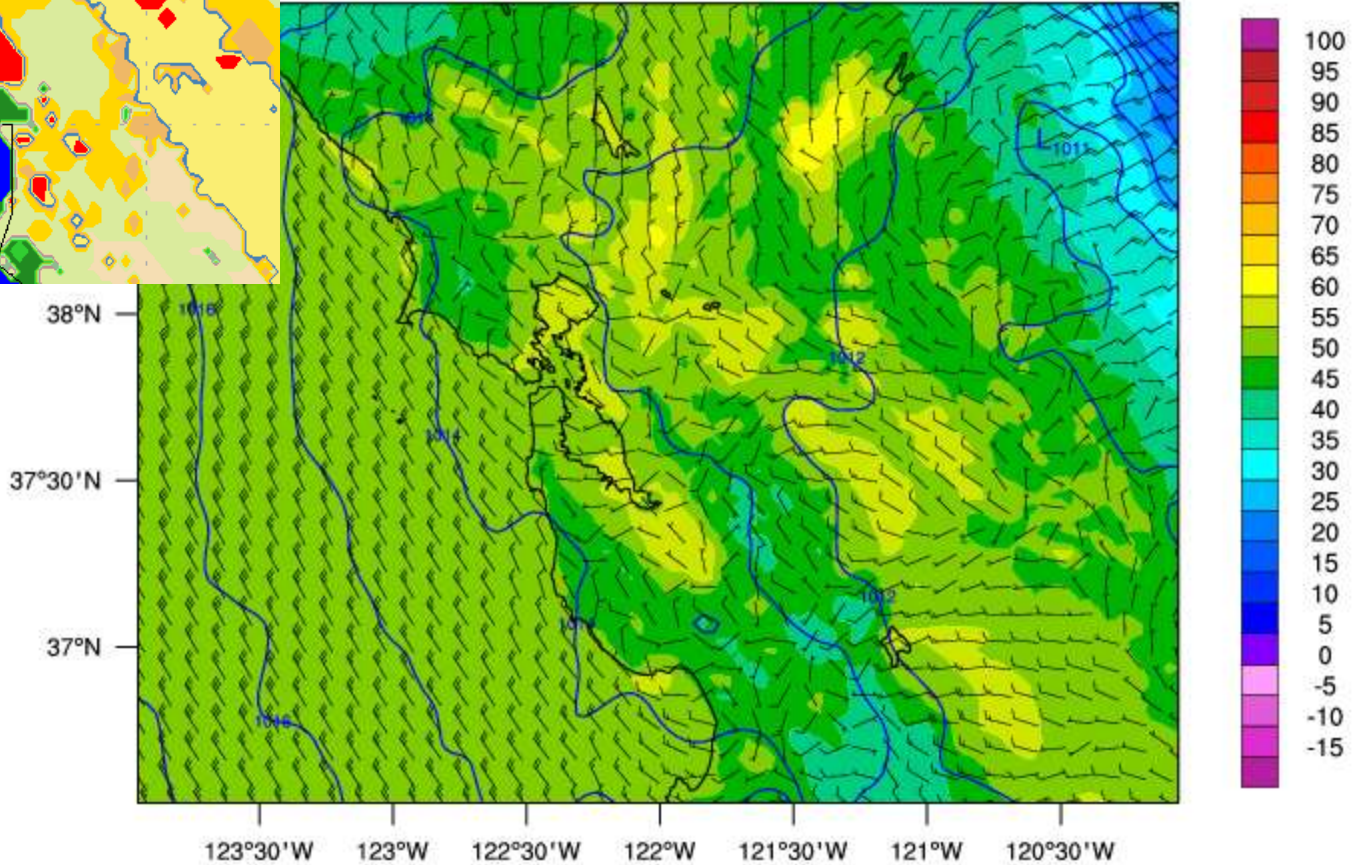
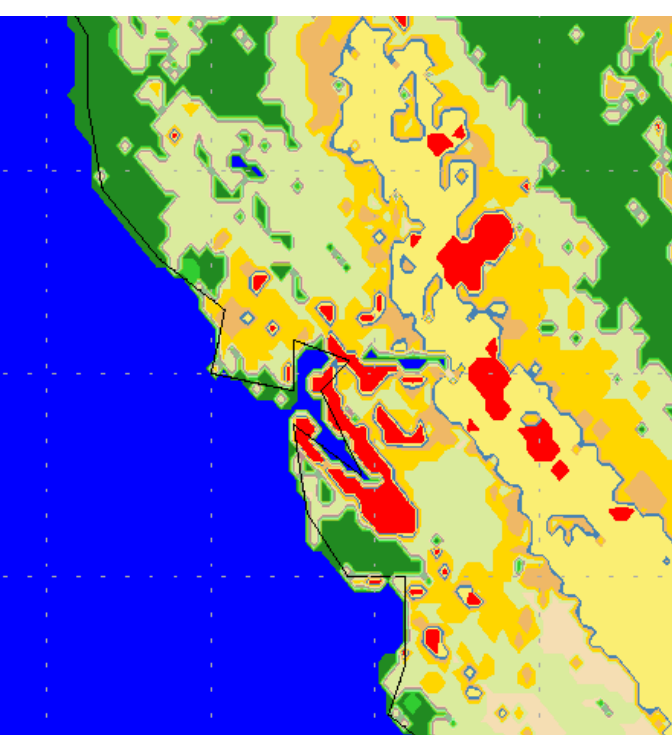
mosphere bulb for it to register a high temperature. In fact, when properly shielded from the sun, the thermometer bulb loses far more energy than it receives and indicates a temperature near absolute zero. This explains why an astronaut, when space walking, will not only survive temperatures exceeding  $1000^{\circ}\text{C}$ , but will also feel a profound coldness when shielded from the sun's radiant energy. At these high altitudes, the traditional meaning of air temperature (that is, regarding how “hot” or “cold” something feels) is no longer applicable.

# San Jose-SF Bay





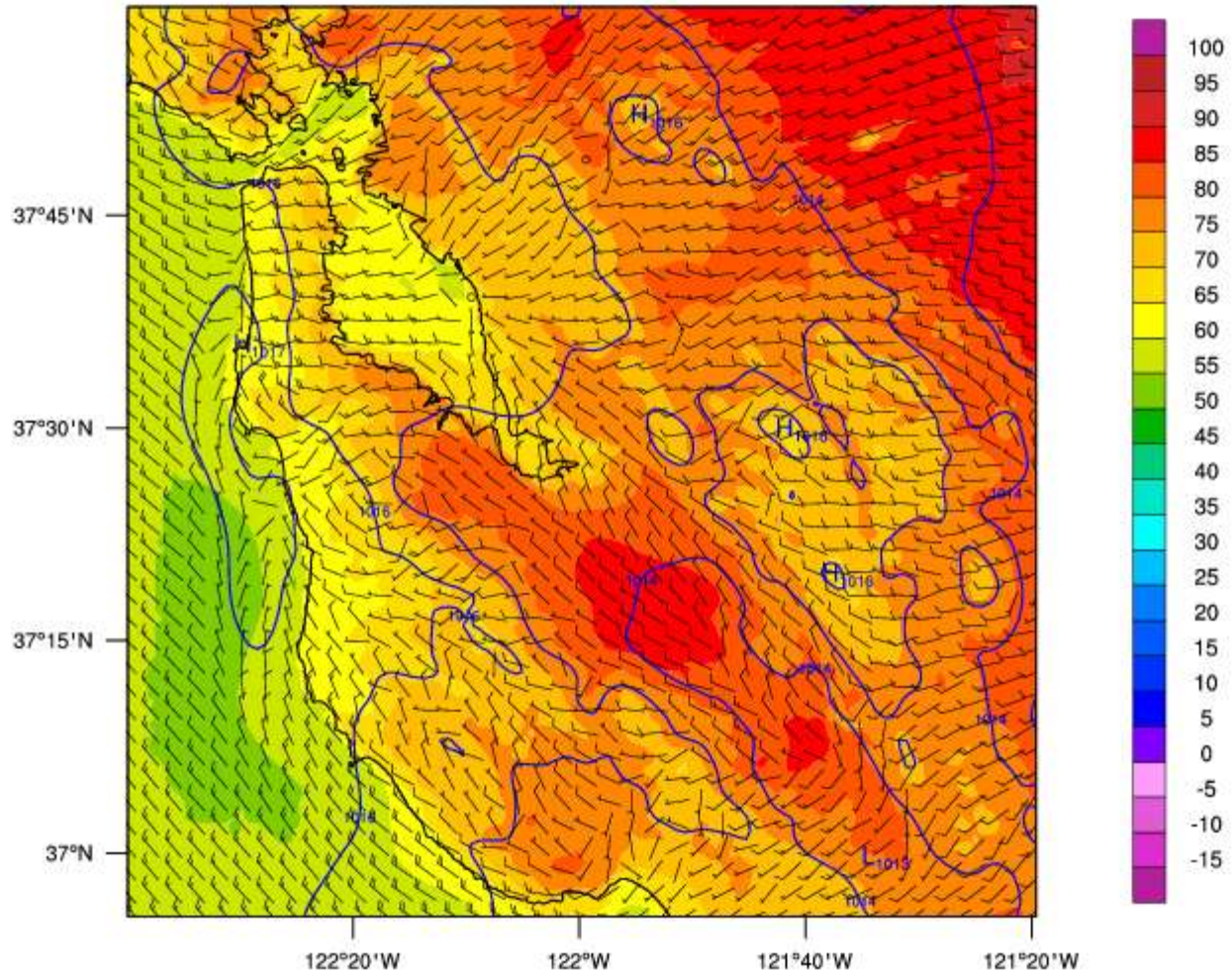
5/9/2011, 8 PM 3 Km





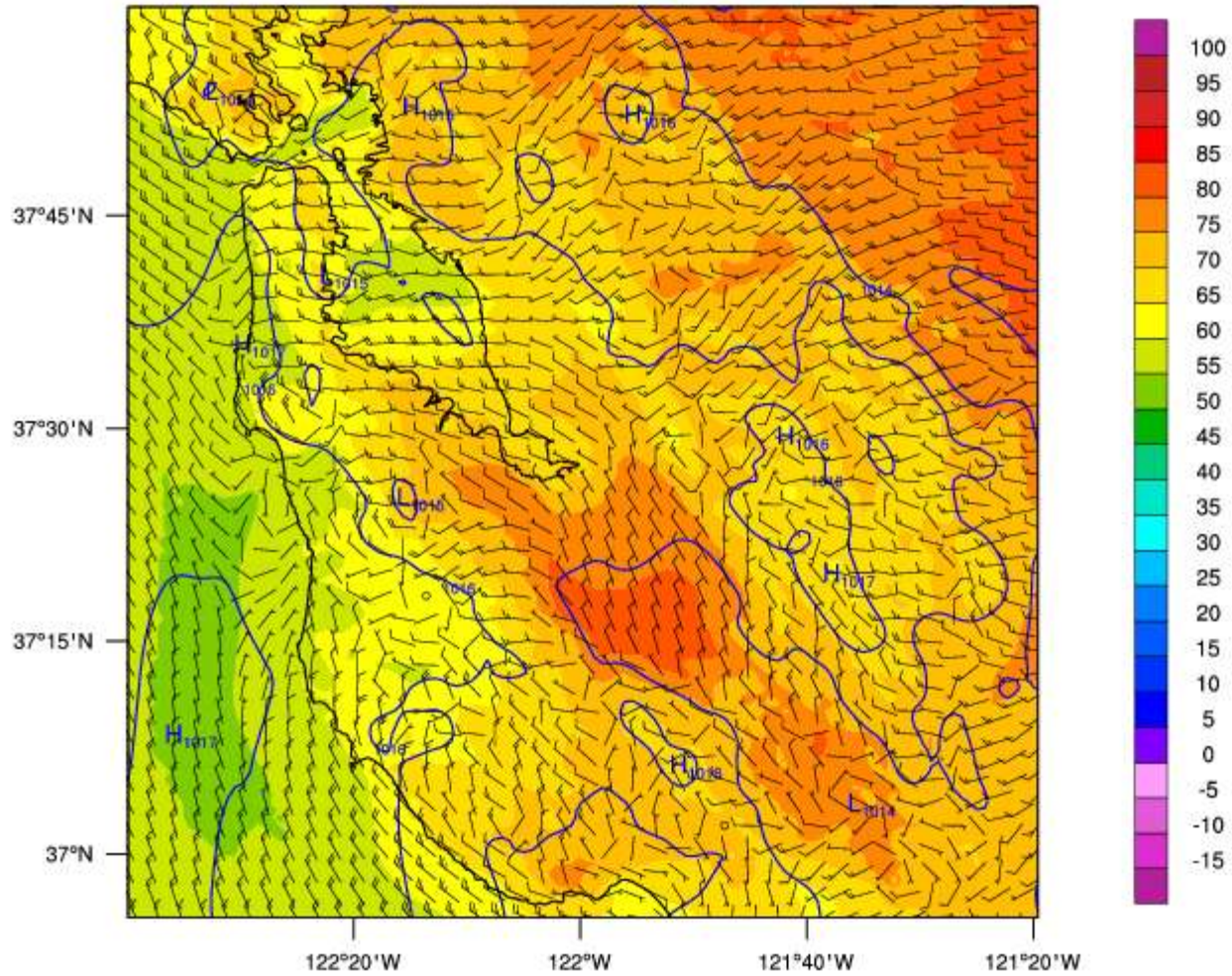
# WRF 1km 5/5/2011 5 PM

Surface Temperature (F)  
Sea Level Pressure (hPa)  
Winds (kts)  
Init 2011-05-06\_00:00:00 / Valid 2011-05-06\_01:00:00 (UTC)



6 PM, 5/5/2011

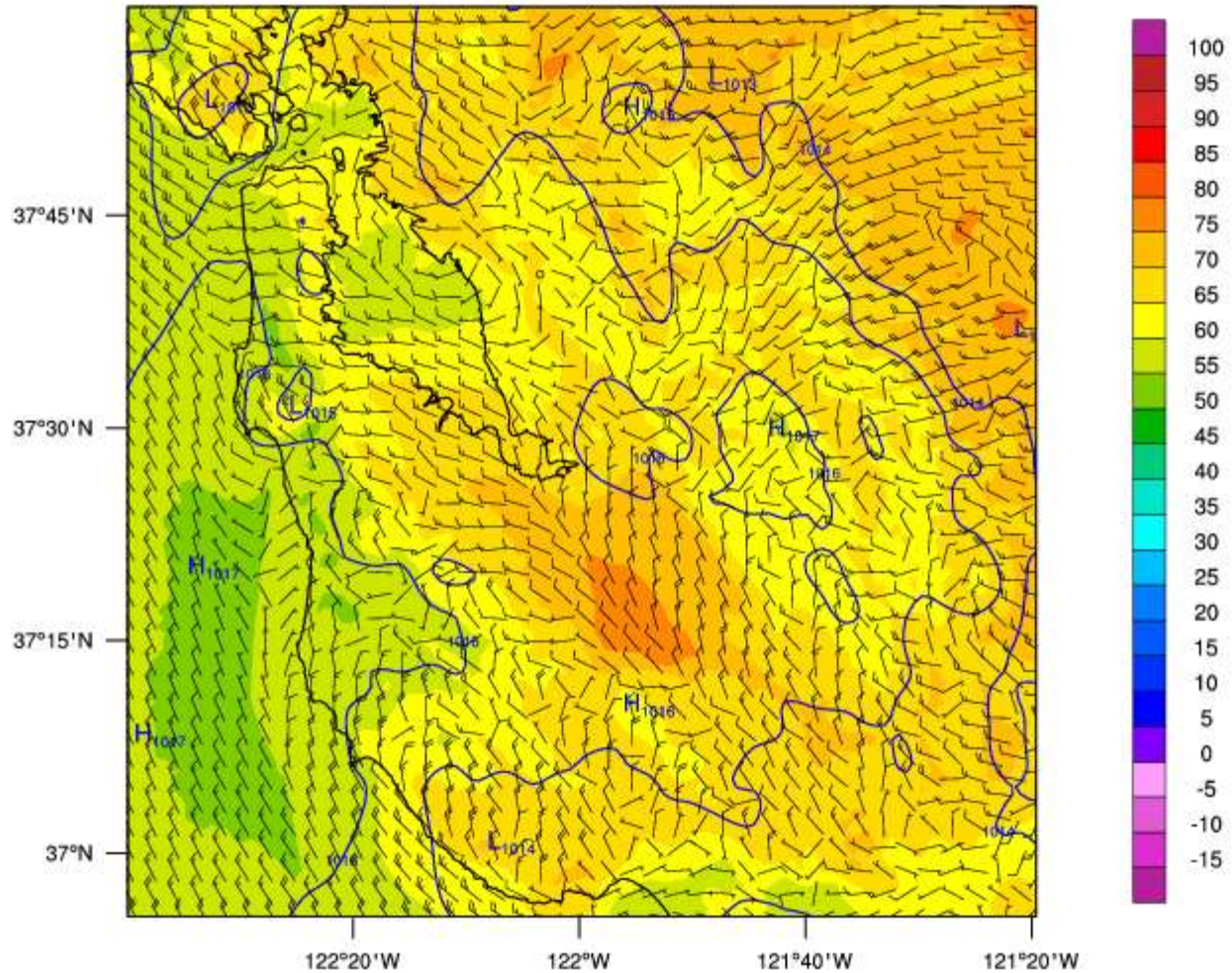
Surface Temperature (F)  
Sea Level Pressure (hPa)  
Winds (kts)  
Init 2011-05-06\_00:00:00 / Valid 2011-05-06\_02:00:00 (UTC)





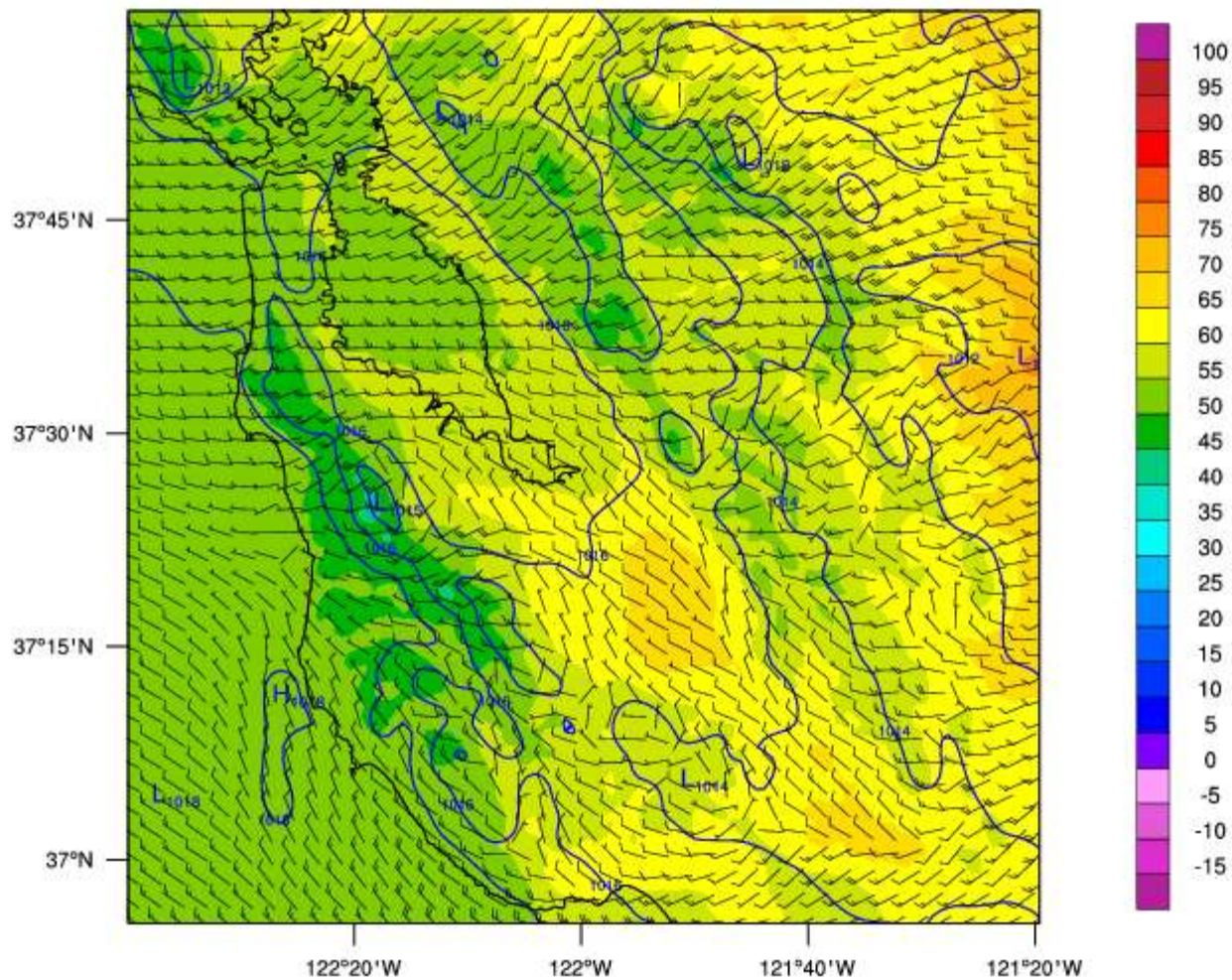
7 PM, 5/5/2011

Surface Temperature (F)  
Sea Level Pressure (hPa)  
Winds (kts)  
Init 2011-05-06\_00:00:00 / Valid 2011-05-06\_03:00:00 (UTC)



5 PM, 5/6/2011

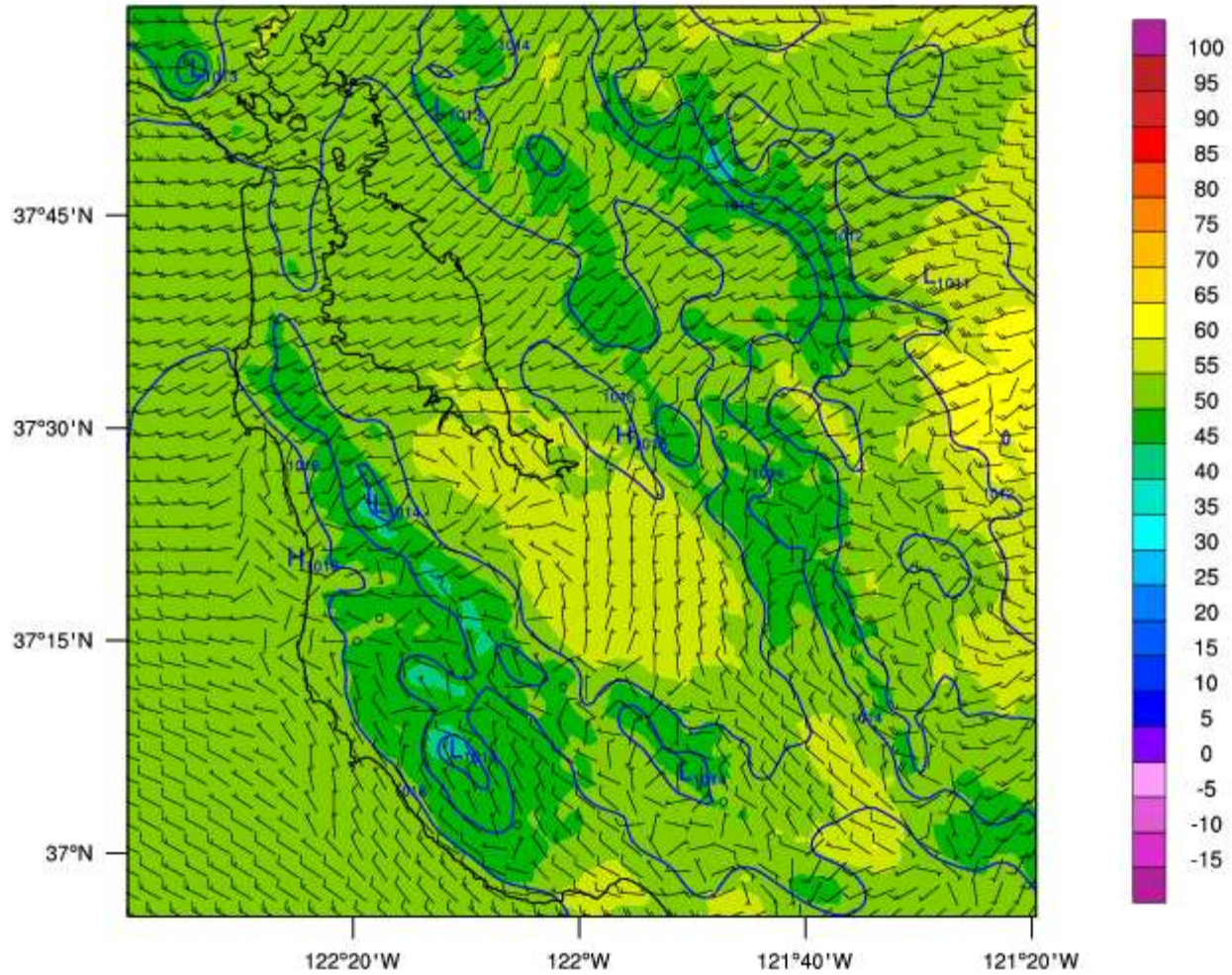
Surface Temperature (F)  
Sea Level Pressure (hPa)  
Winds (kts)  
Init 2011-05-07\_00:00:00 / Valid 2011-05-07\_01:00:00 (UTC)





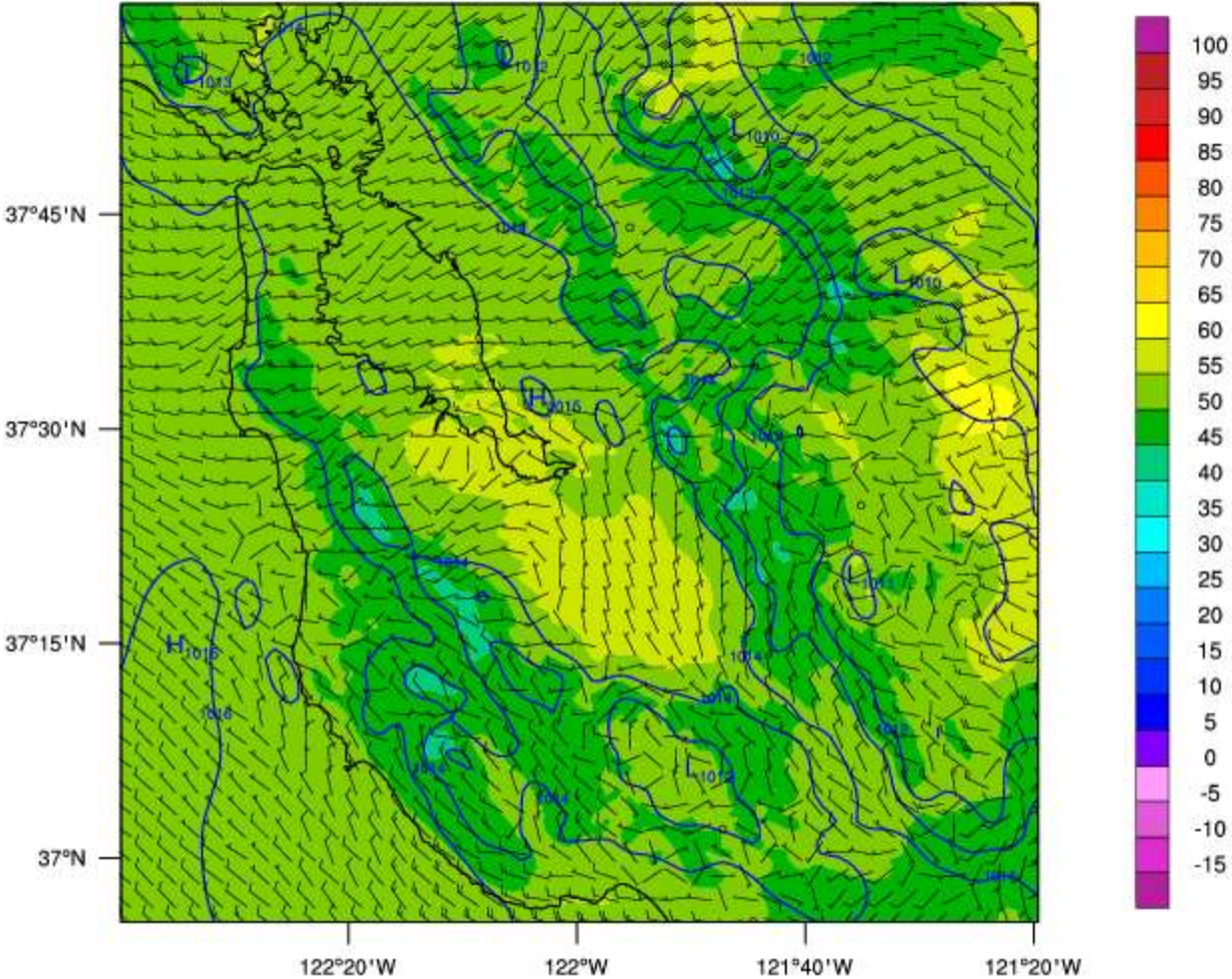
Surface Temperature (F)  
Sea Level Pressure (hPa)  
Winds (kts)  
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7 PM, 5/6/2011



9 PM, 5/6/2011

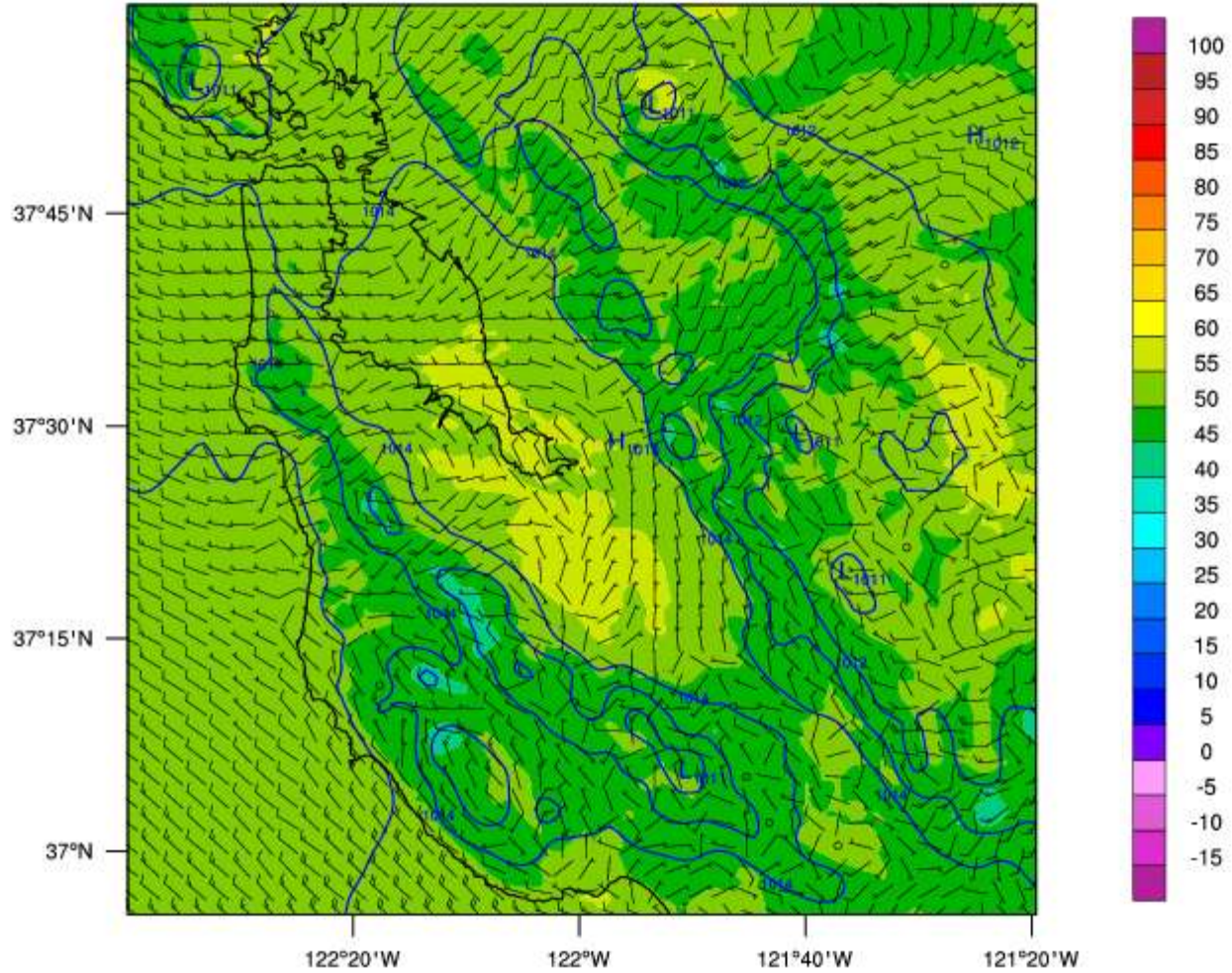
Surface Temperature (F)  
Sea Level Pressure (hPa)  
Winds (kts)  
Init 2011-05-07\_00:00:00 / Valid 2011-05-07\_05:00:00 (UTC)





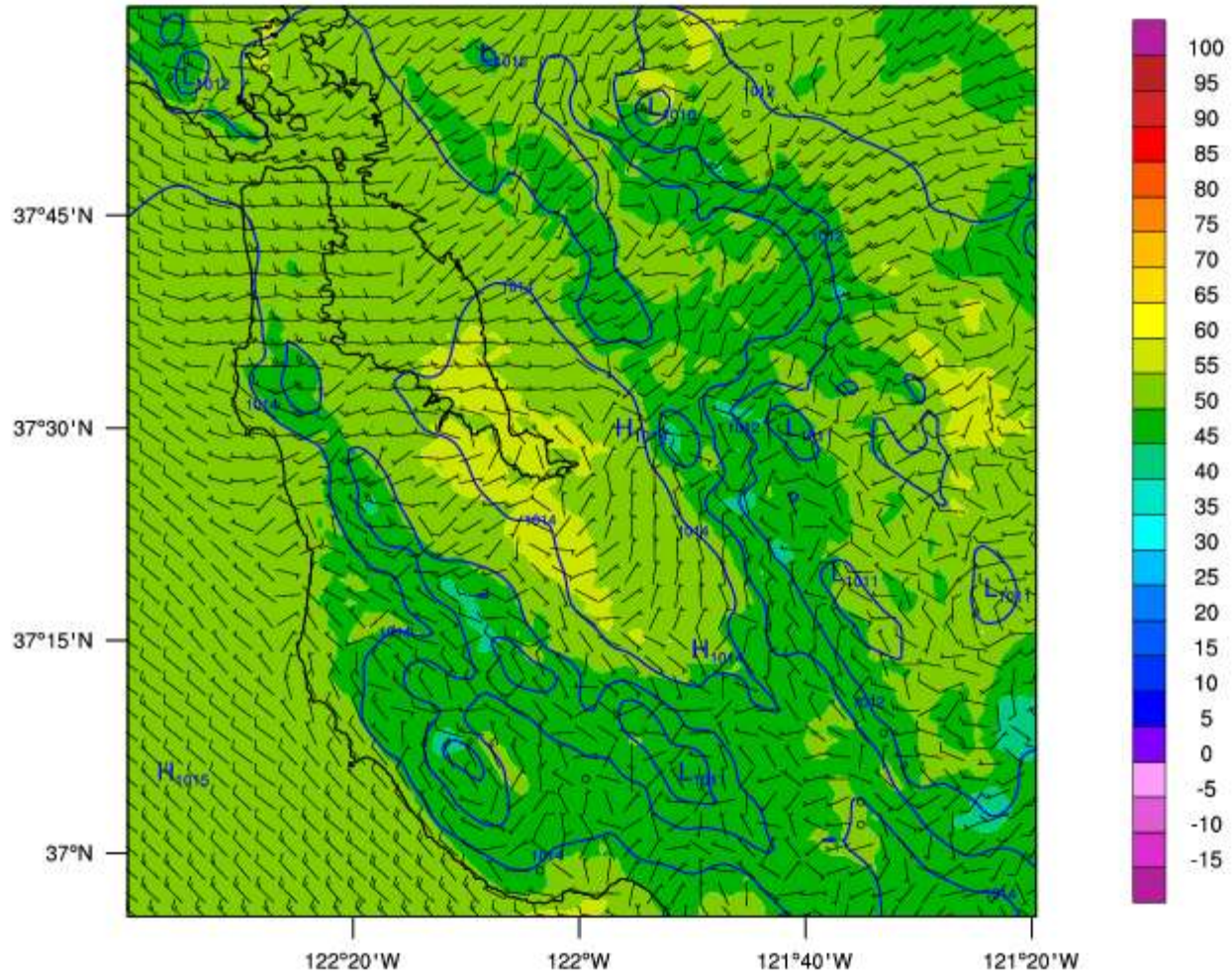
Surface Temperature (F)  
Sea Level Pressure (hPa)  
Winds (kts)  
Init 2011-05-07\_00:00:00 / Valid 2011-05-07\_07:00:00 (UTC)

11 PM, 5/6/2011



1 AM, 5/7/2011

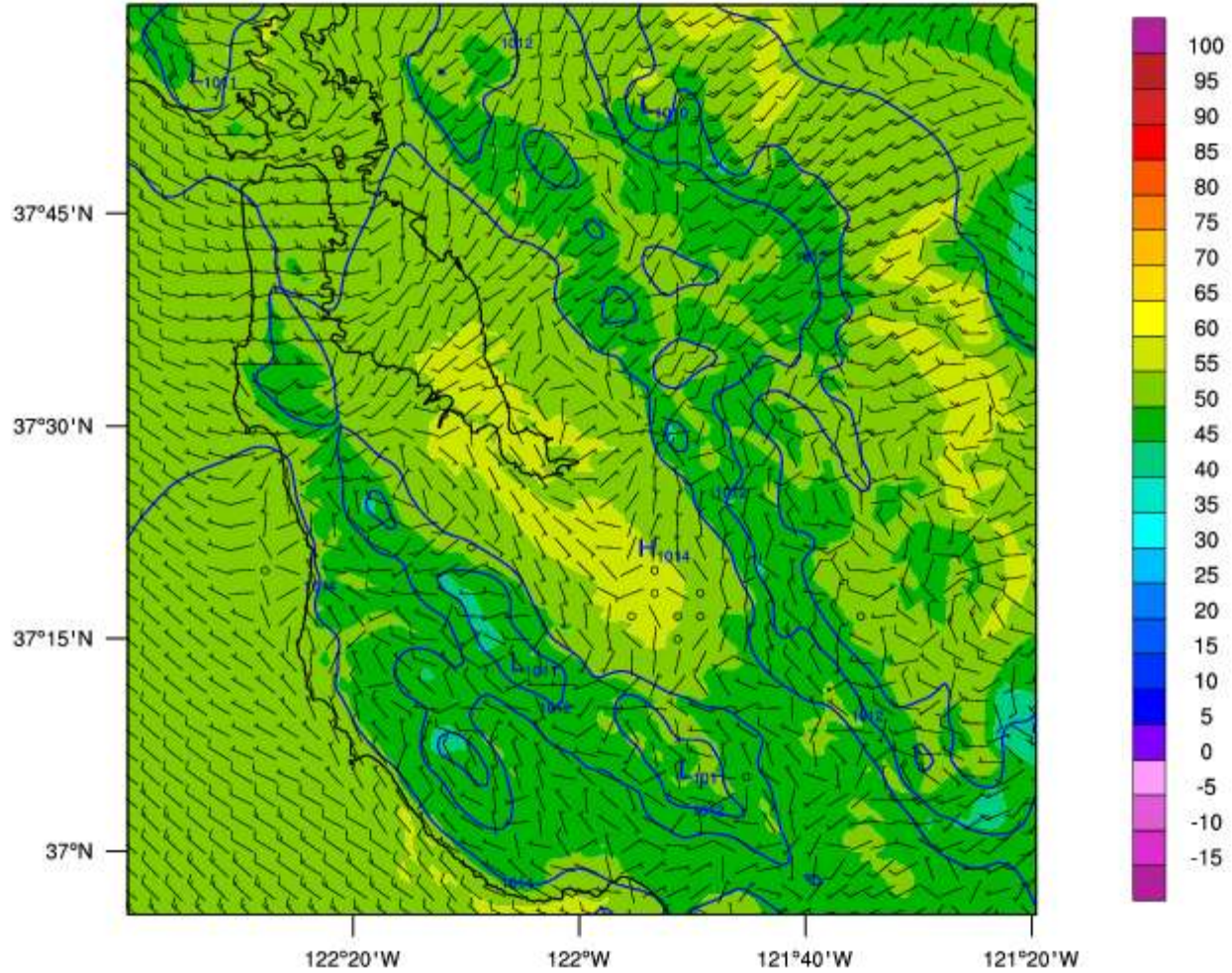
Surface Temperature (F)  
Sea Level Pressure (hPa)  
Winds (kts)  
Init 2011-05-07\_00:00:00 / Valid 2011-05-07\_09:00:00 (UTC)





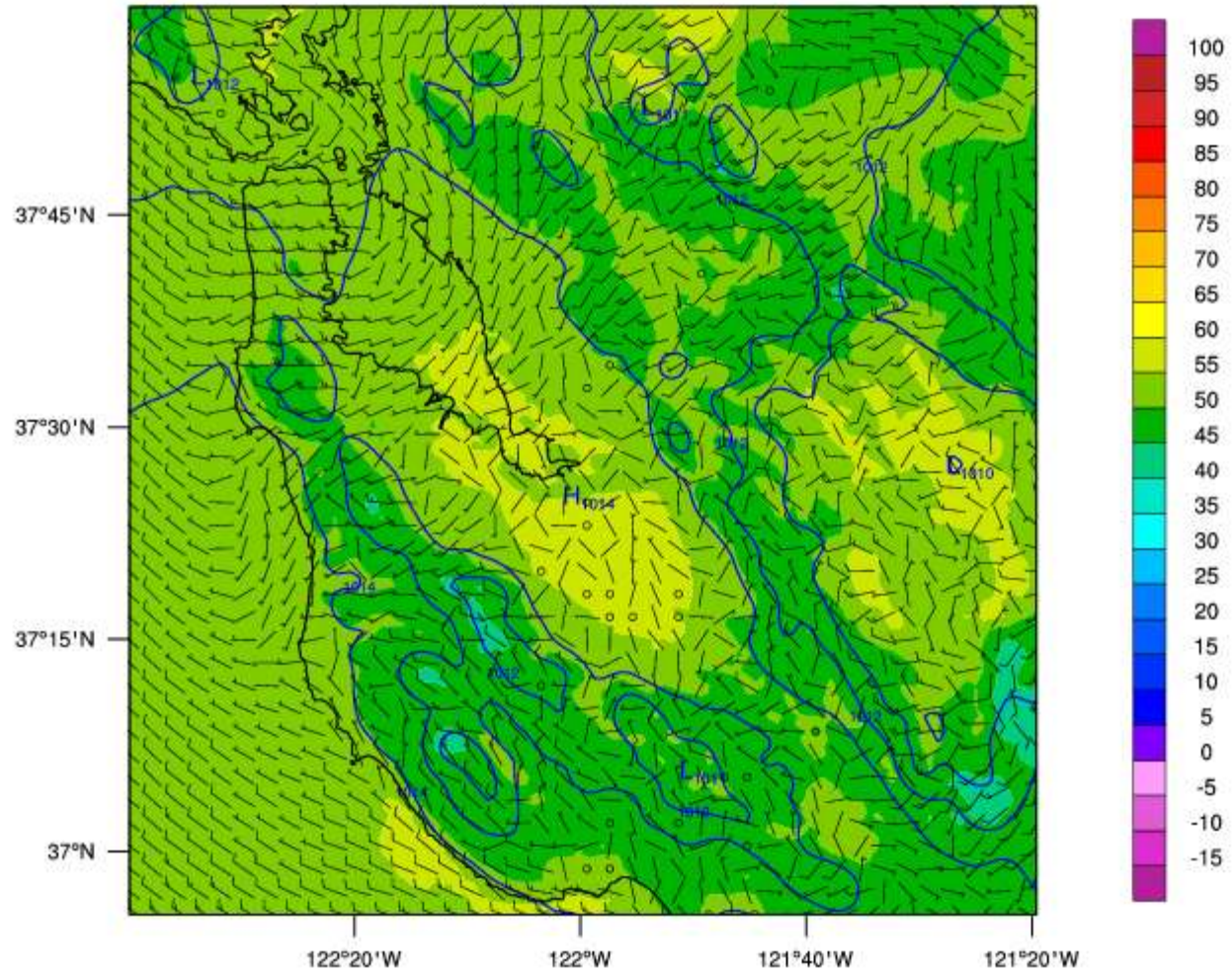
Surface Temperature (F)  
Sea Level Pressure (hPa)  
Winds (kts)  
Init 2011-05-07\_00:00:00 / Valid 2011-05-07\_11:00:00 (UTC)

3 AM, 5/7/2011



Surface Temperature (F)  
Sea Level Pressure (hPa)  
Winds (kts)  
Init 2011-05-07\_00:00:00 / Valid 2011-05-07\_13:00:00 (UTC)

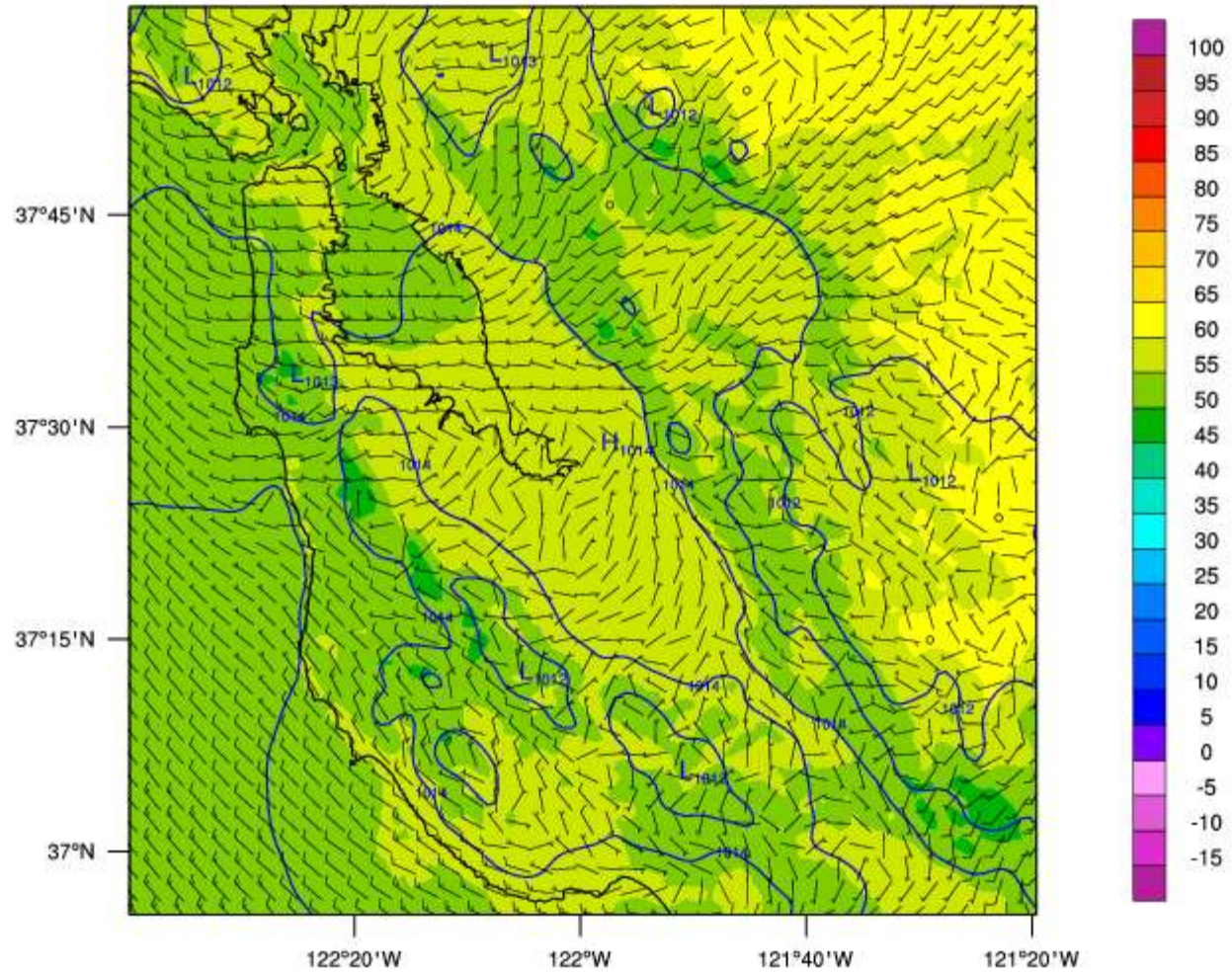
5 AM, 5/7/2011





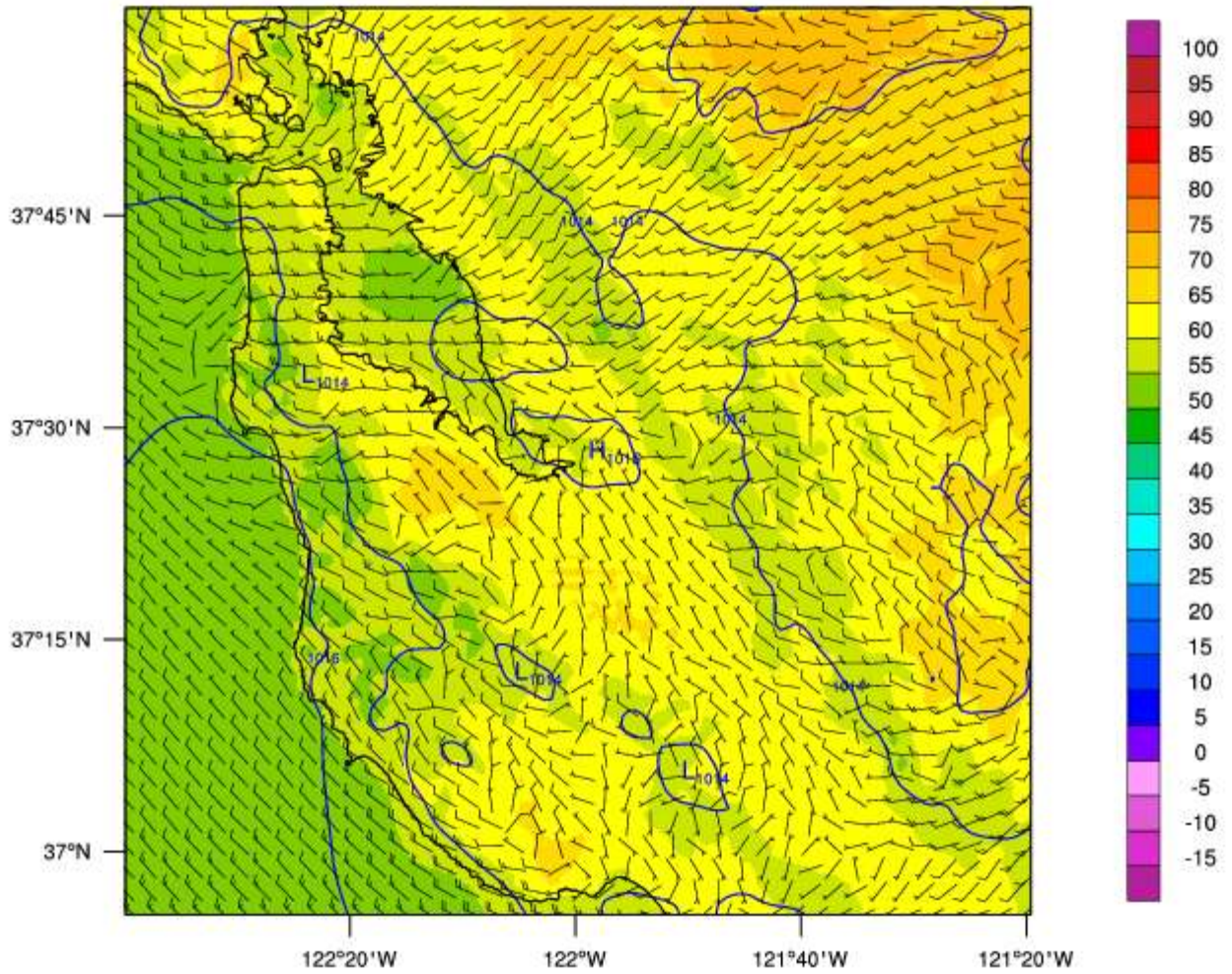
8 AM, 5/7/2011

Surface Temperature (F)  
Sea Level Pressure (hPa)  
Winds (kts)  
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10 AM, 5/7/2011

Surface Temperature (F)  
Sea Level Pressure (hPa)  
Winds (kts)  
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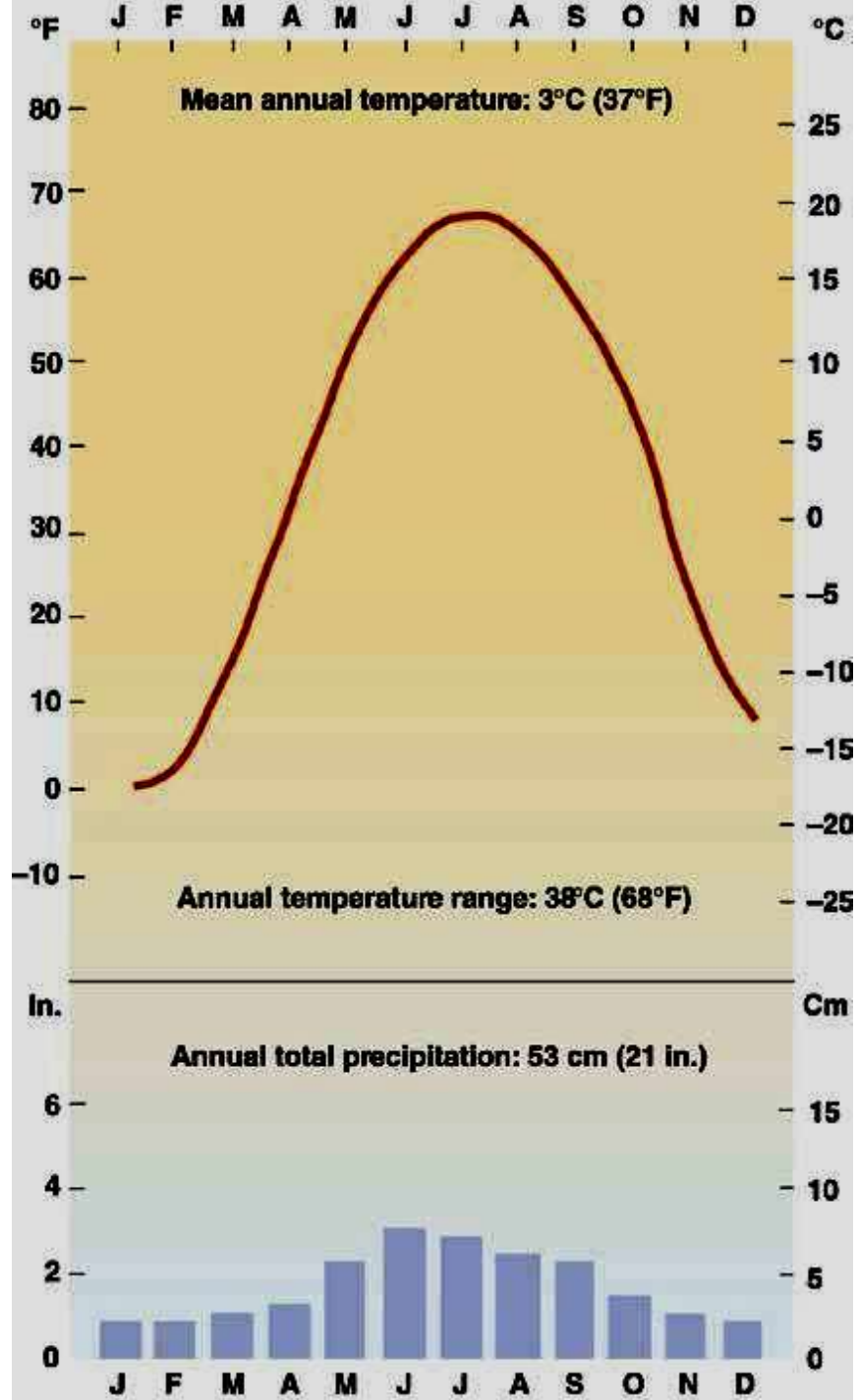




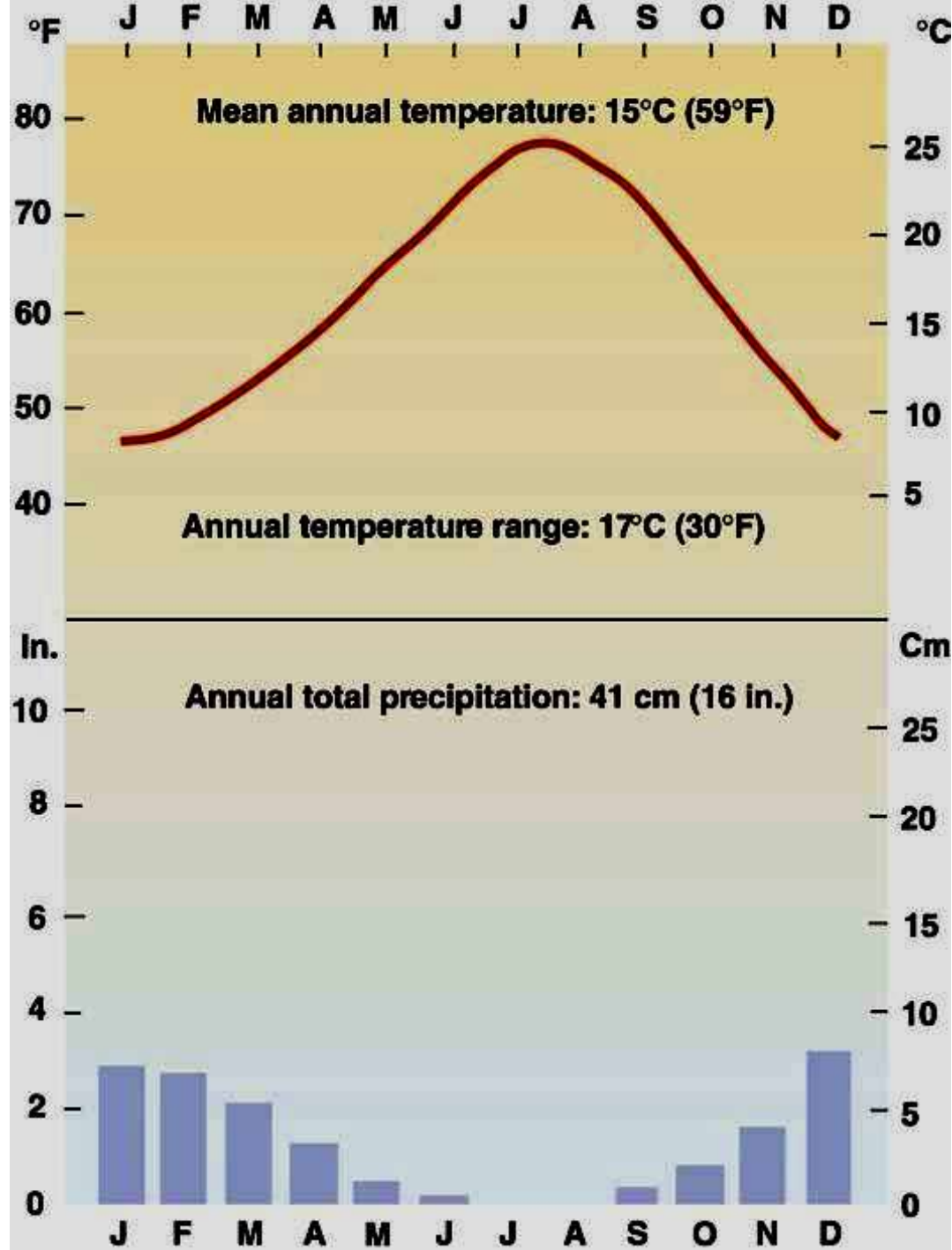
**Vi nastupate**

**Klimatska igra!**

# Grad A

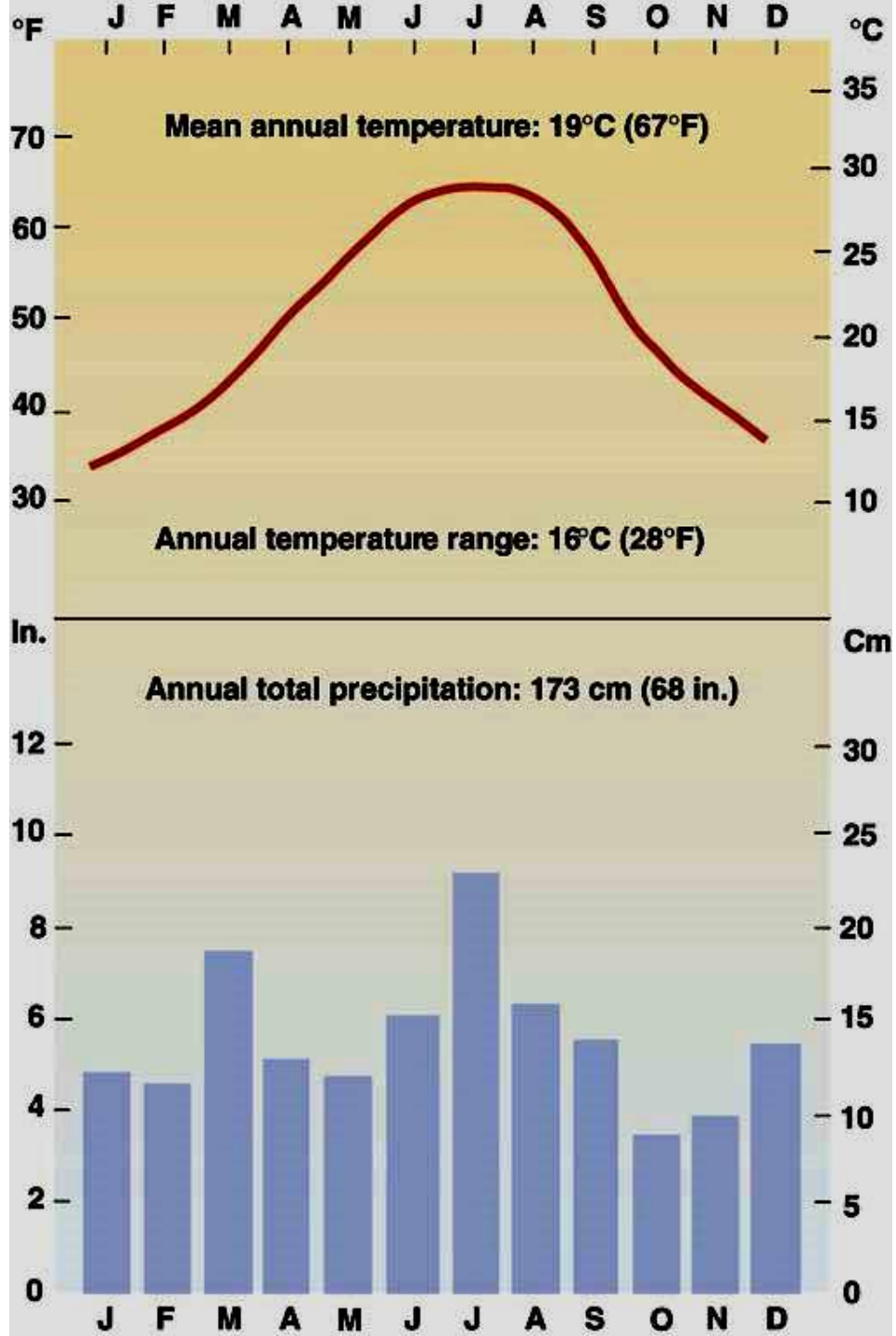


# Grad B

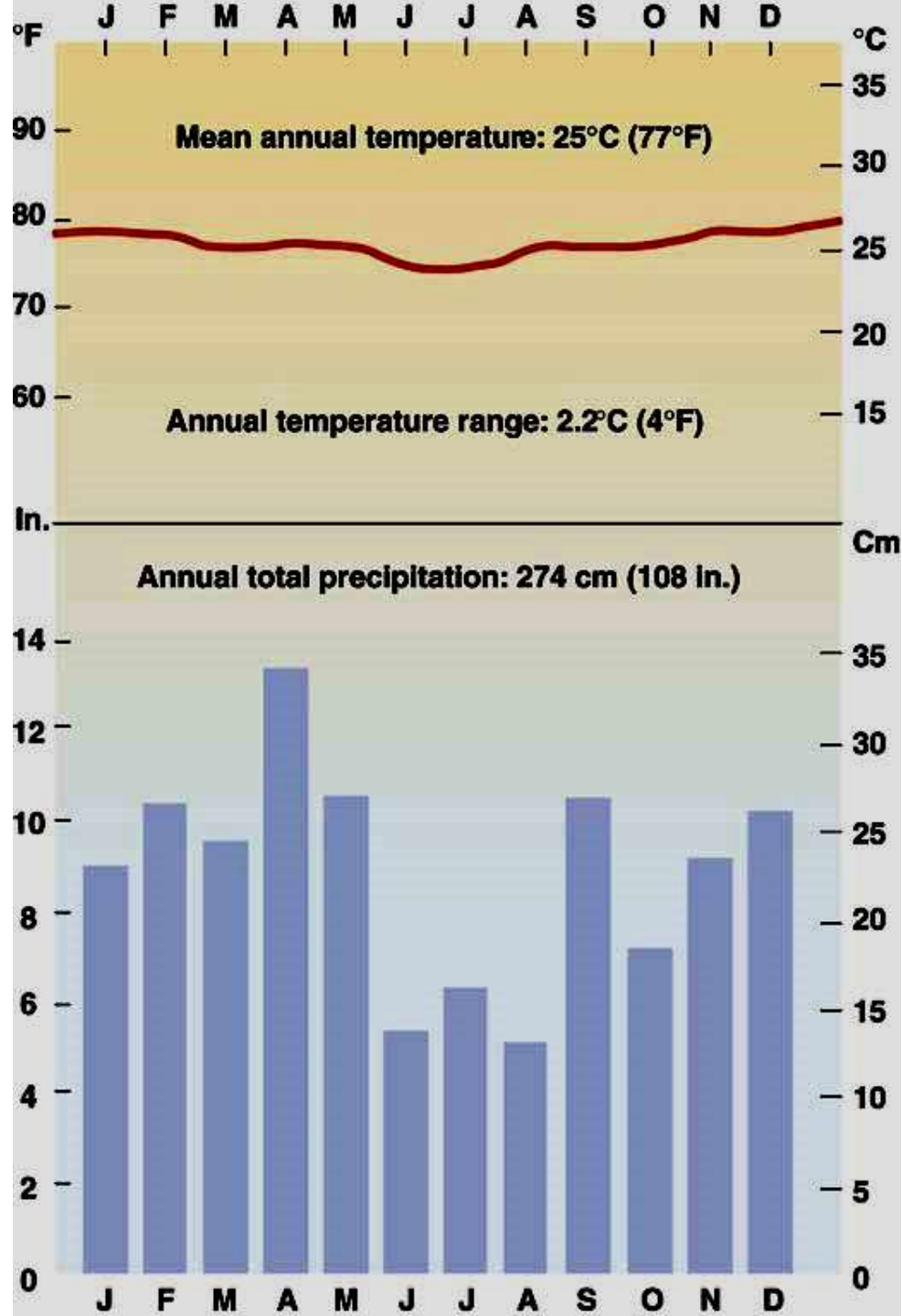




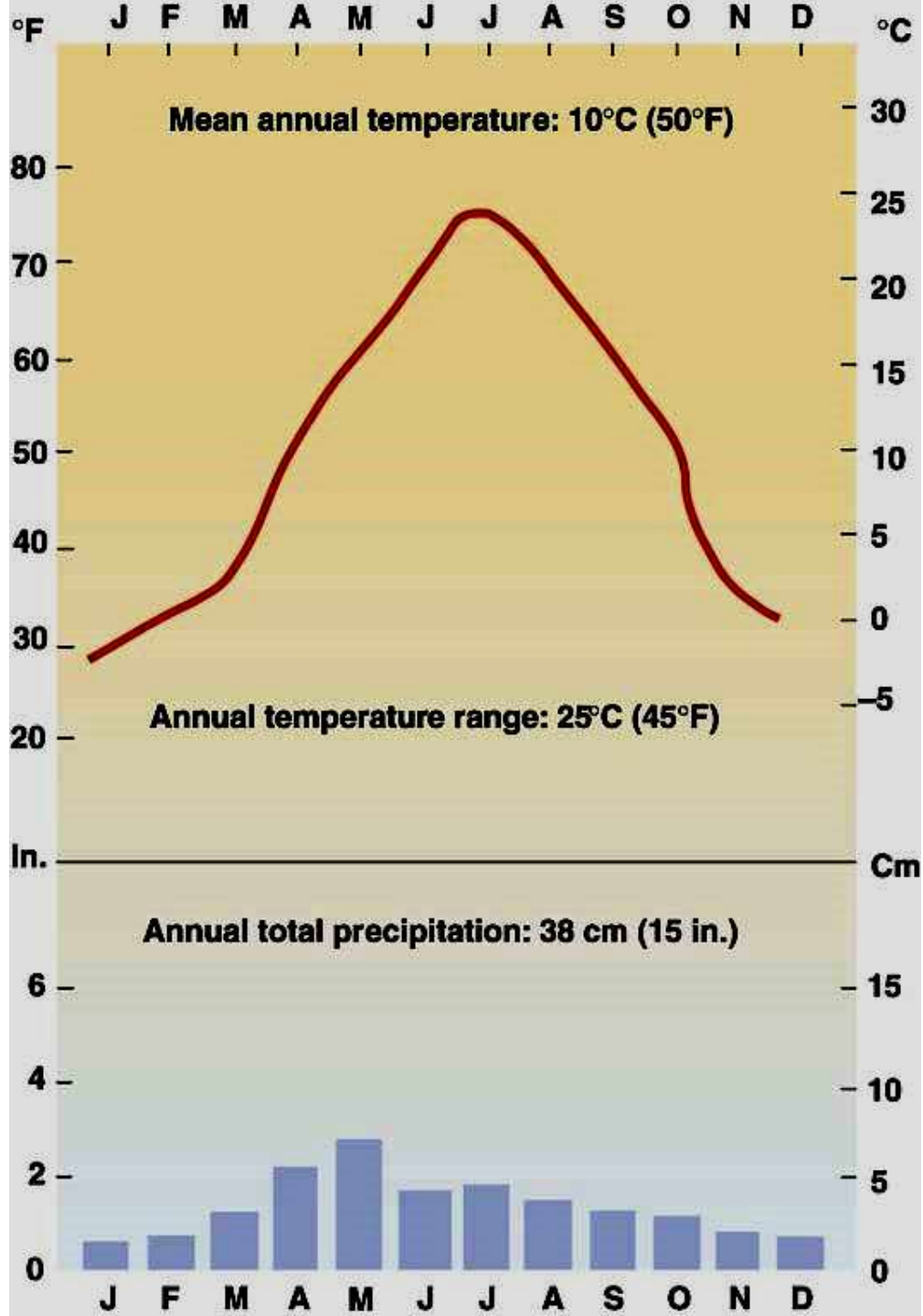
# Grad C



# Grad D

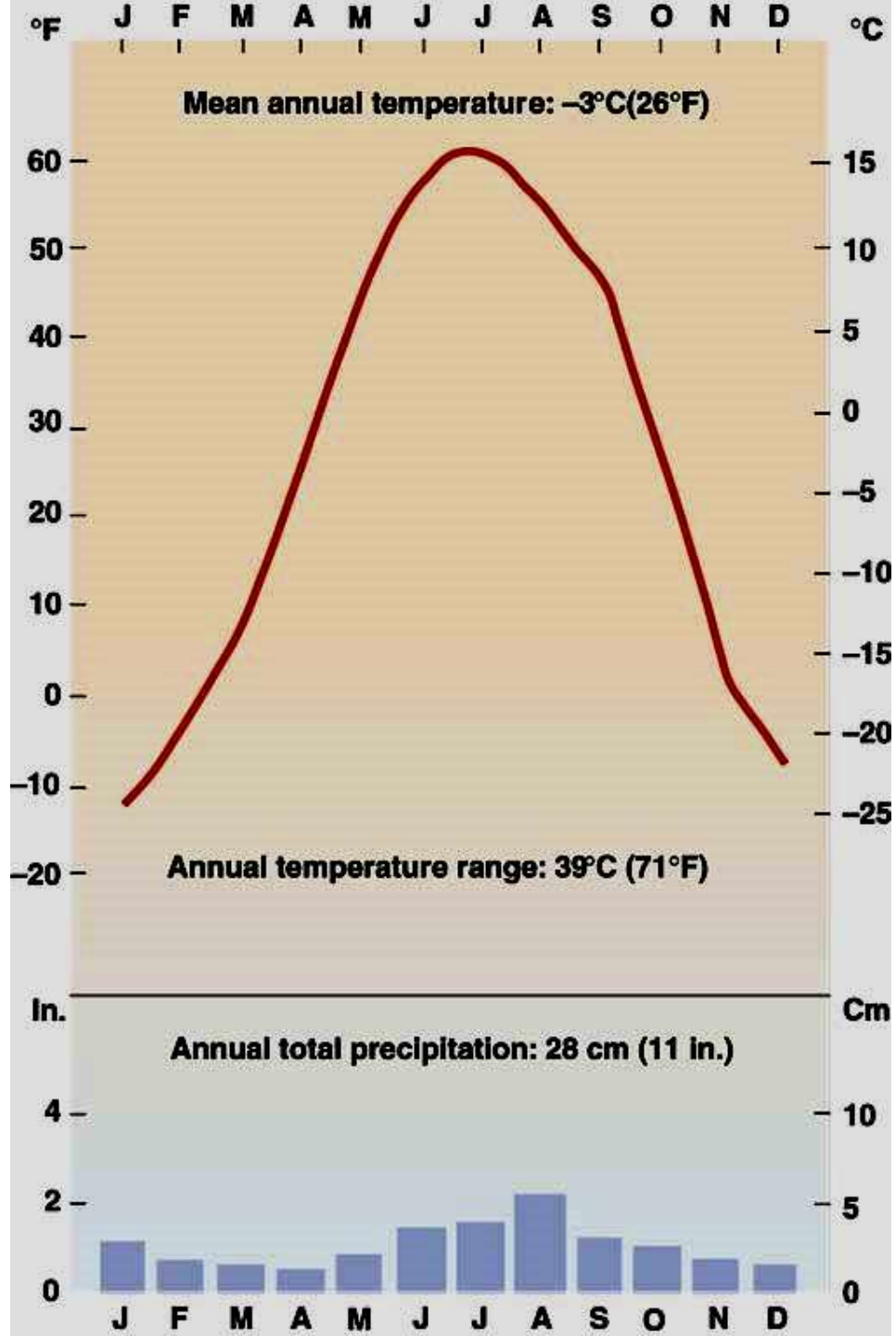


# Grad E

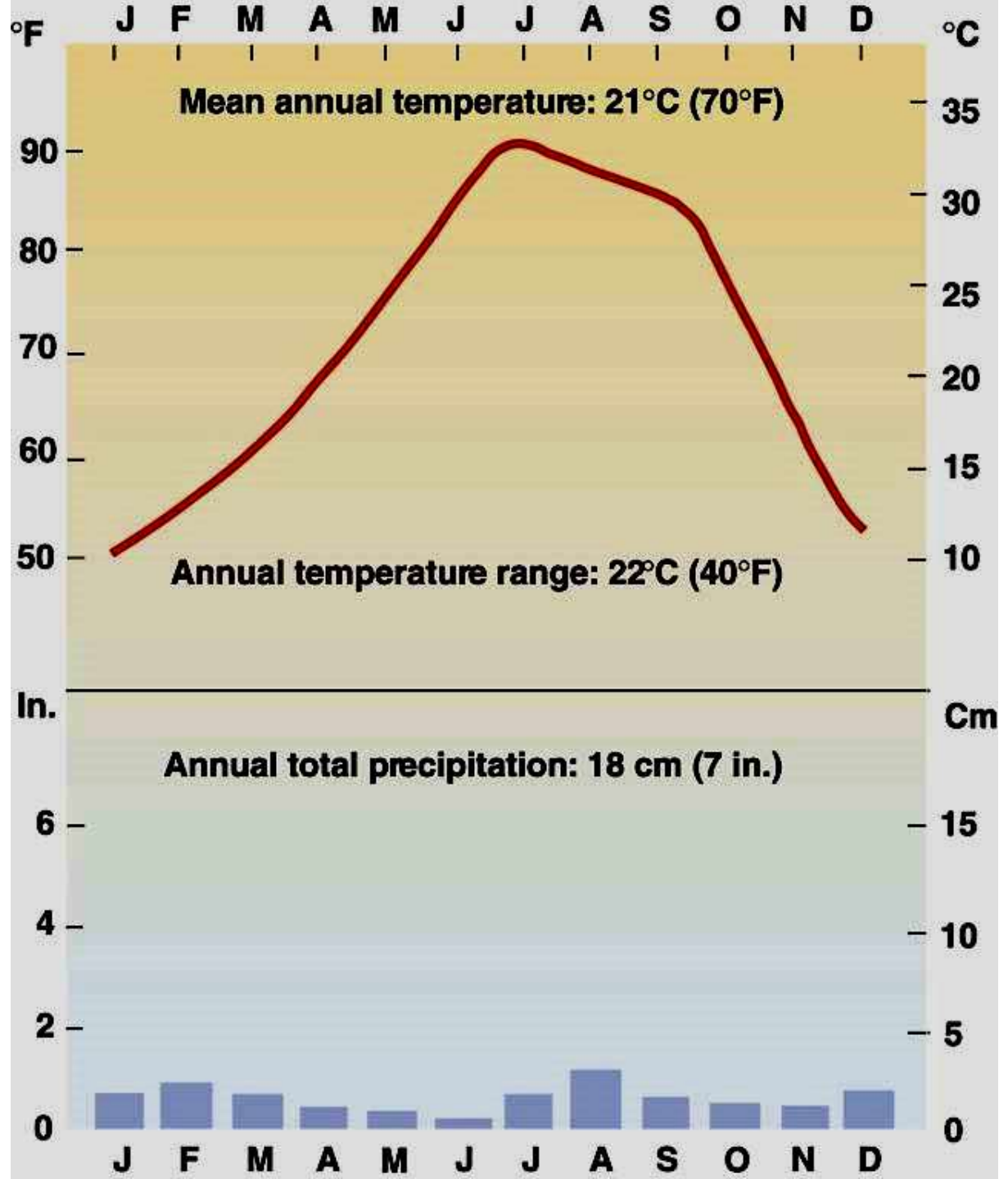




# Grad F



# Grad G



# Klimatska igra

## Nazivi

Pored naziva gradova upišite slovo za odgovarajuću klimu

Sacramento, California (38°N)	_____	B
Phoenix, Arizona (33°N)	_____	G
Denver, Colorado (40°N)	_____	E
Iquitos, Peru (4°S)	_____	D
Mobile, Alabama (30°N)	_____	C
Winnipeg, Canada (50°N)	_____	A
Fairbanks, Alaska (65°N)	_____	F