Climate system and climate change

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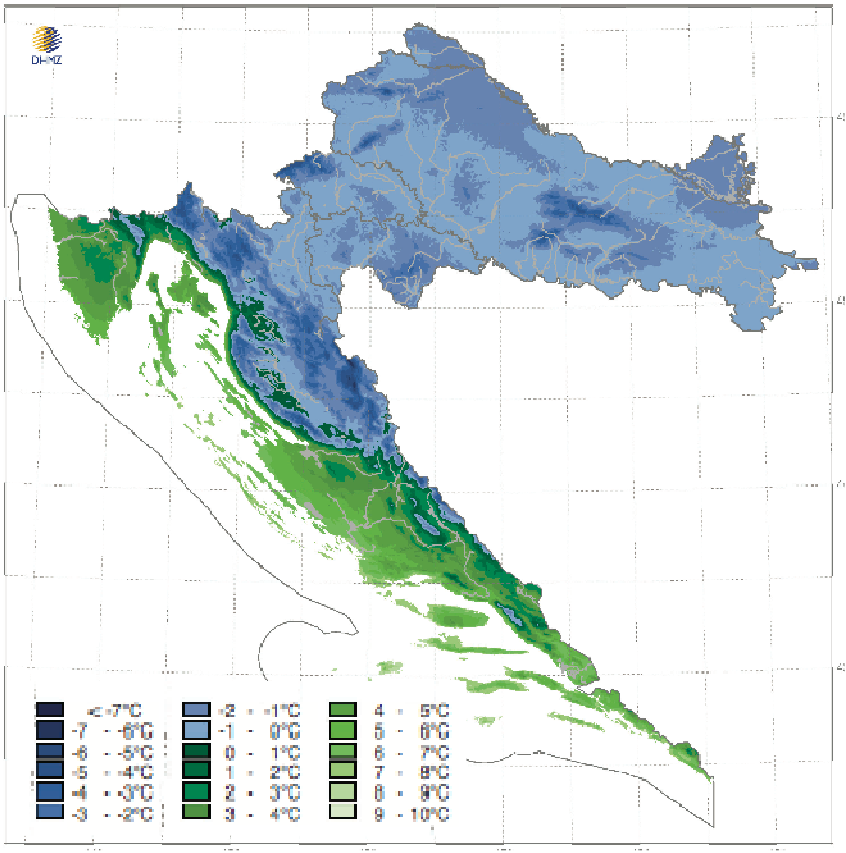
Outline

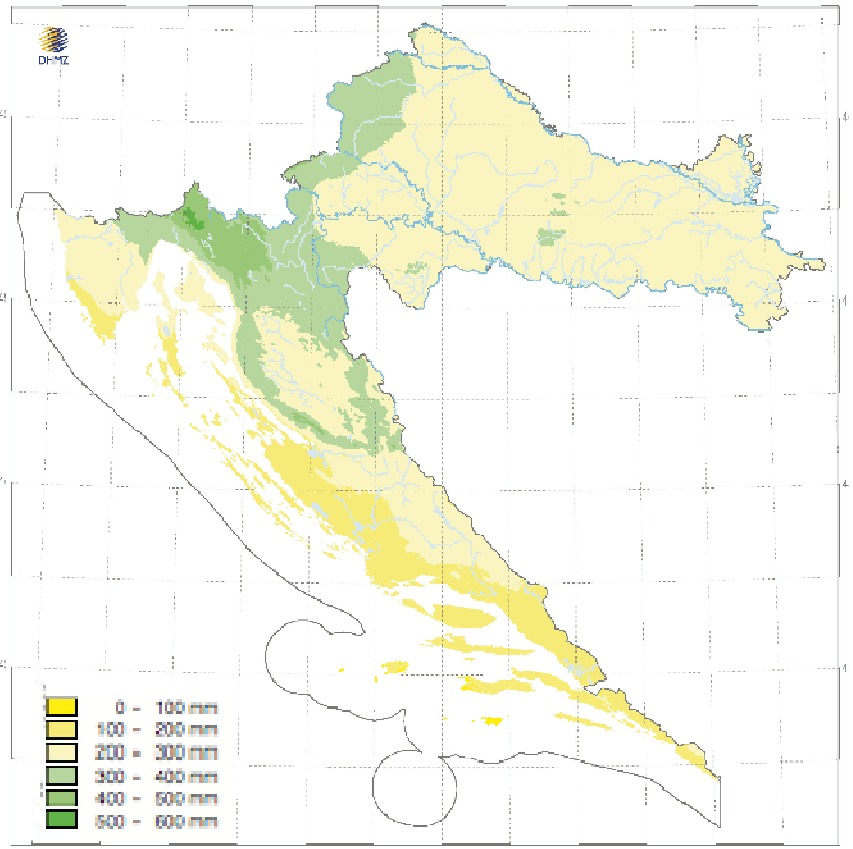
1. Observed climate of Croatia
2. Climate system
3. Climate variability and climate change
4. Observed climate change
5. Future climate change

Observed climate of Croatia

Mean air temperature January 1961-1990



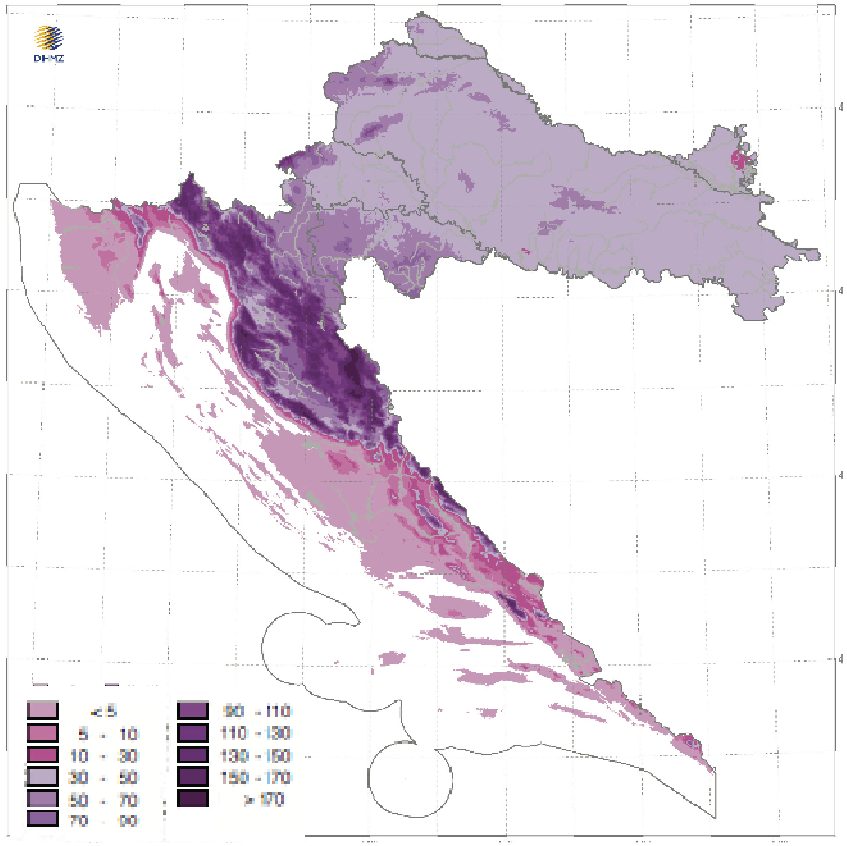
Mean precipitation July 1961-1990



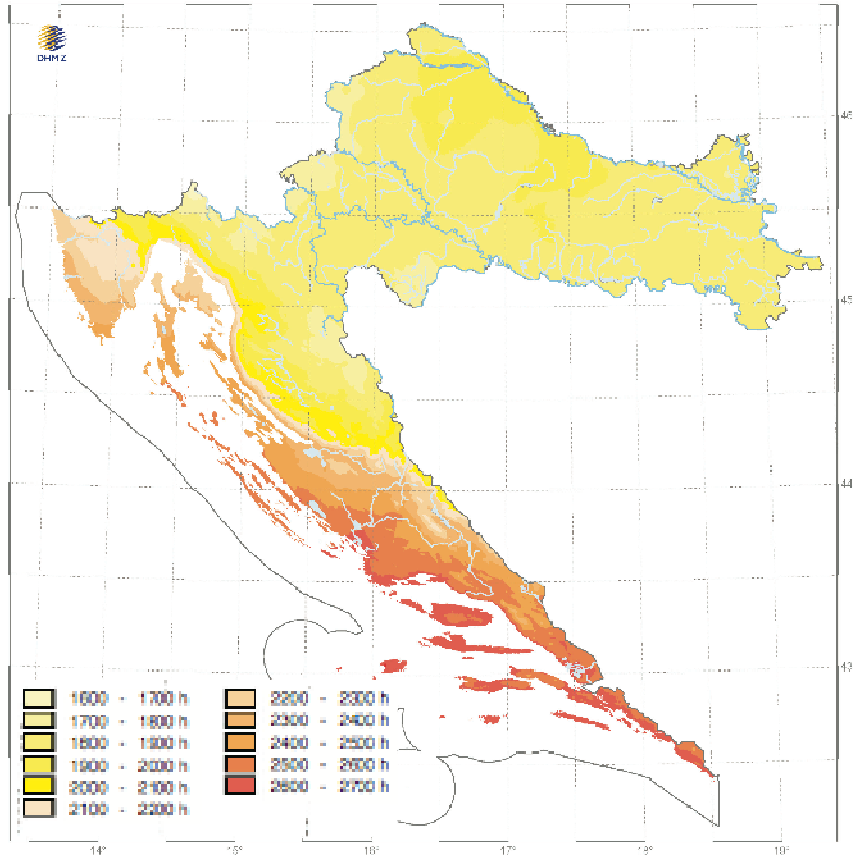
Source: Zaninović et al. (2008) Climate atlas of Croatia

Observed climate of Croatia

Mean annual number of days with snow cover ≥ 1 cm



Mean annual insolation duration (hours)



Source: Zaninović et al. (2008) Climate atlas of Croatia

What is climate?

* Climate of an area for a given period is defined by expected values of meteorological variables

* Climate is the "average weather" - a statistical description of weather, including variability and extremes

* Climate is only external manifestation of climate processes, dynamics and interactions of components of climate system

* Components of climate system are atmosphere, hydrosphere (oceans, seas, lakes), cryosphere (ice cover, sea ice), land surface, biosphere (vegetation)

* Climate of an area is affected by its latitude, elevation, proximity to large water bodies (oceans, seas, lakes), topography, prevailing winds, ...

* Climate variables (elements): solar radiation, air temperature, air pressure, wind direction and speed, humidity, precipitation, evaporation, snow cover, ...

Climate system

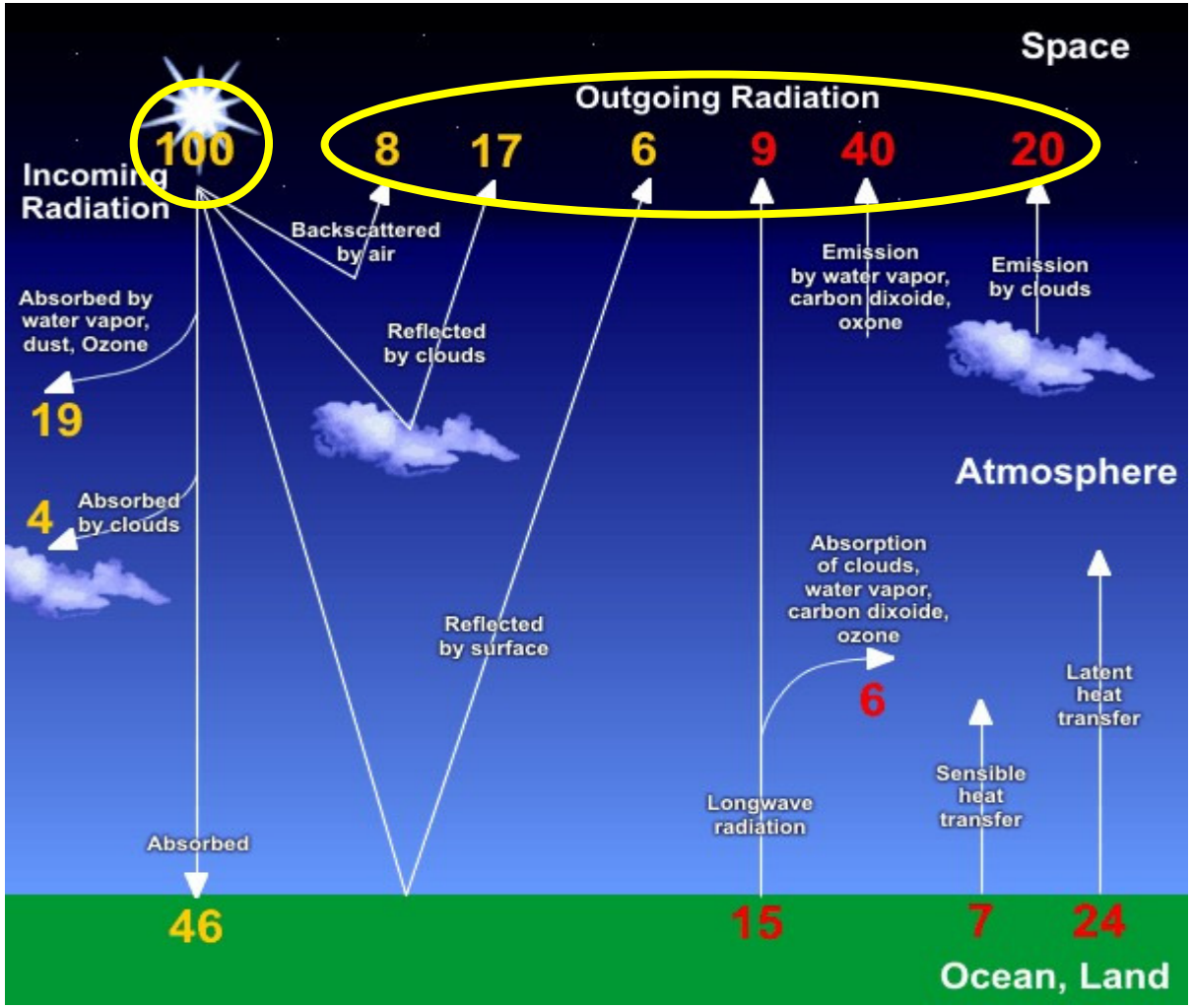
* Earth's climate is a solar powered system

* Atmosphere and oceans redistribute solar heating from the equator towards the poles - Earth's heat engine

* Earth's heat engine also simultaneously radiates heat from the surface and lower atmosphere back to space

* The net flow of energy into and out of the Earth system is Earth's energy budget

Earth's energy budget

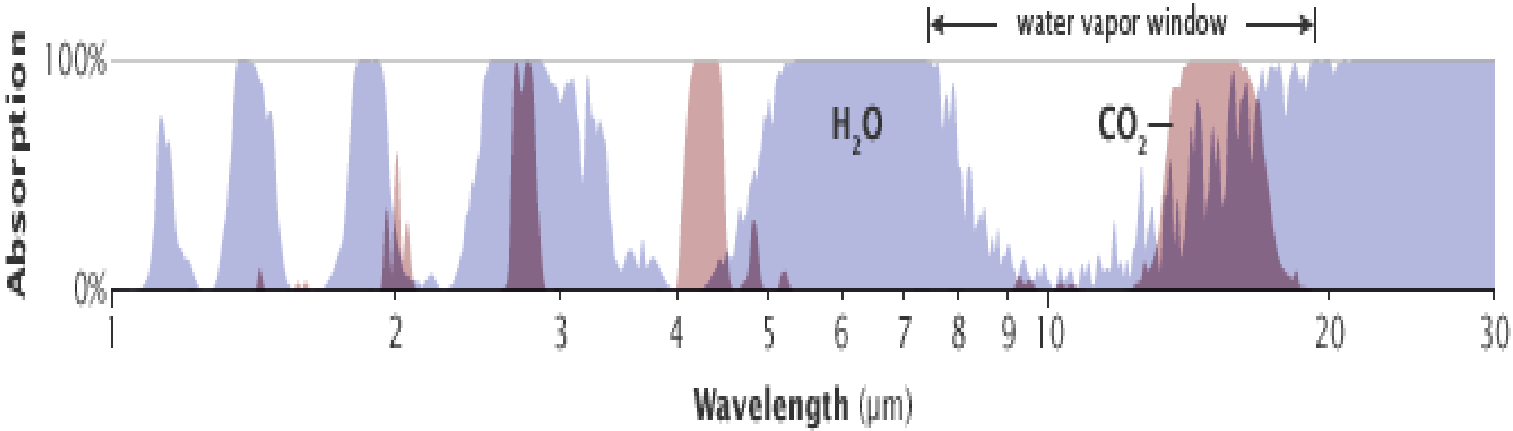


Source: Internet

Earth's energy budget

* Absorbtion by atmospheric gases

* The role of water vapour and CO_2



Source: earthobservatory.nasa.gov

Climate variability and climate change

Key terms

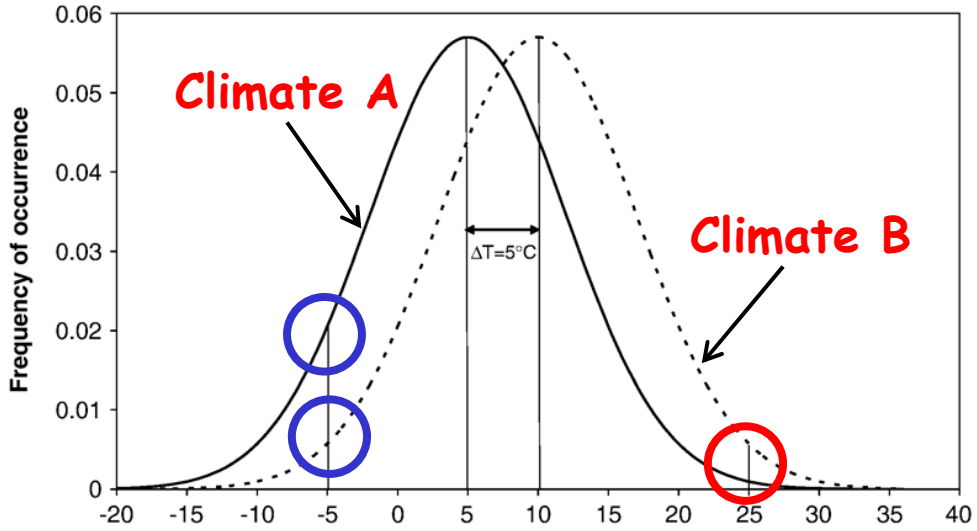
* Climatological normal
    * long-term (usually 30-year) average of a weather variable

* Climate variability
    * fluctuations above or below climatological normal on short time scales
    * denotes deviations (anomalies) of climatic statistics over a given period of time
    * due to natural internal processes within the climate system (internal variability), or to variations in natural or anthropogenic external factors (external variability)

* Climate change
    * long-term continuous and significant change to average weather conditions (or to statistical distribution of weather events)
    * on time scales of decades to millions of years

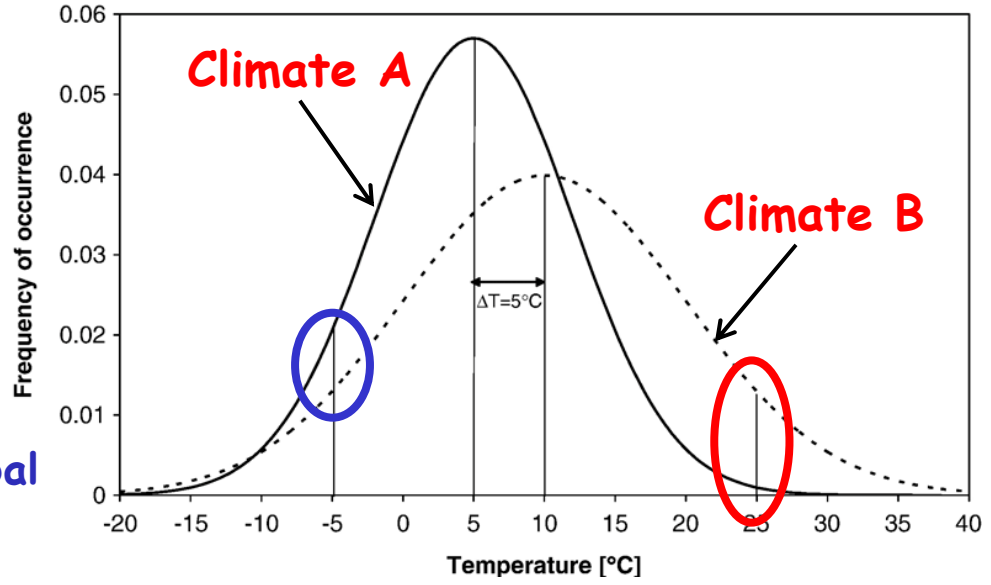
Climate variability and climate change

* Frequency of occurrence



Shift in the frequency of occurrence with same variability

Shift in the frequency of occurrence with increased variability



Source: Beniston and Goyette, Global and Planetary Change (2007)

Causes of climate change

* Change in Earth's energy balance

* Natural causes of climate change

    * variation in the Sun's energy reaching Earth
    * changes in Earth's orbit
    * volcanic eruptions (aerosols)

* Anthropogenic causes of climate change

    * deforestation
    * land use
    * burning of fossil fuels

They cause the increase in CO_2 levels, aerosols, ozone depletion

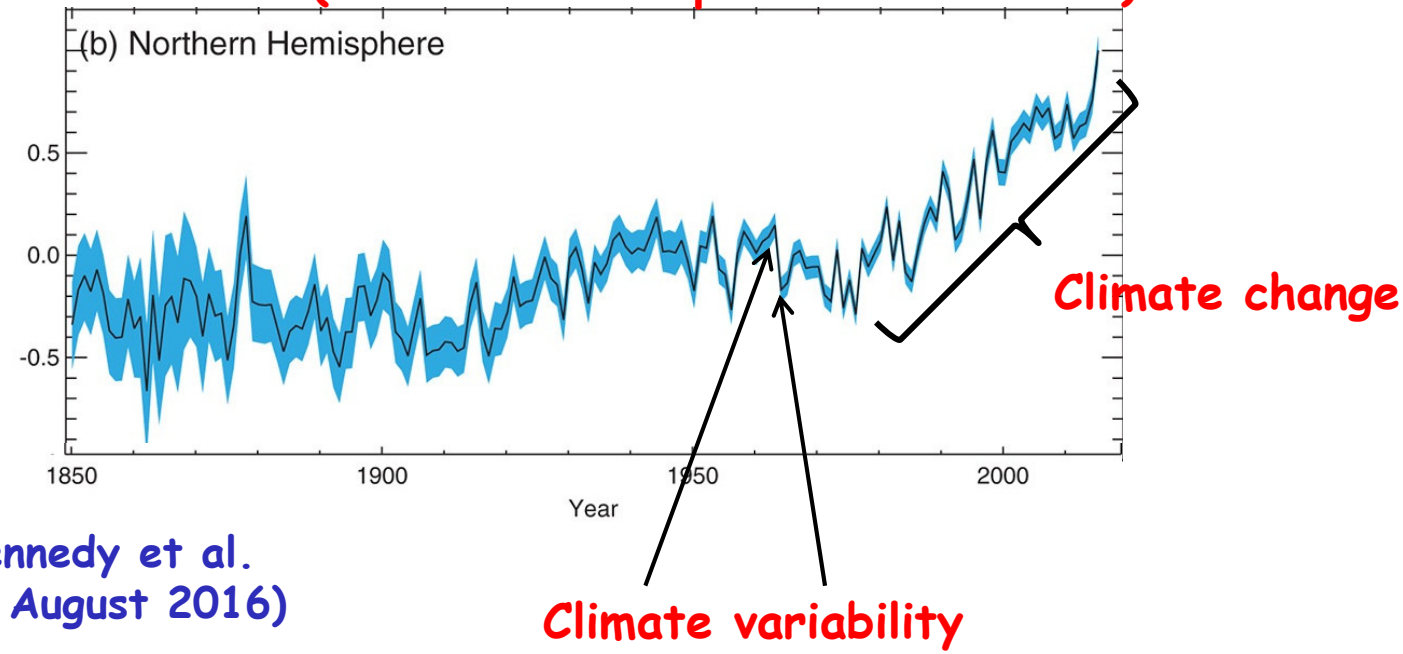
Observed climate change

* Climate variability and climate change contribute to modern climate

* Climate variability is "superimposed" on the climate change long-term evolution

* Detection of climate change over a short time period may be difficult

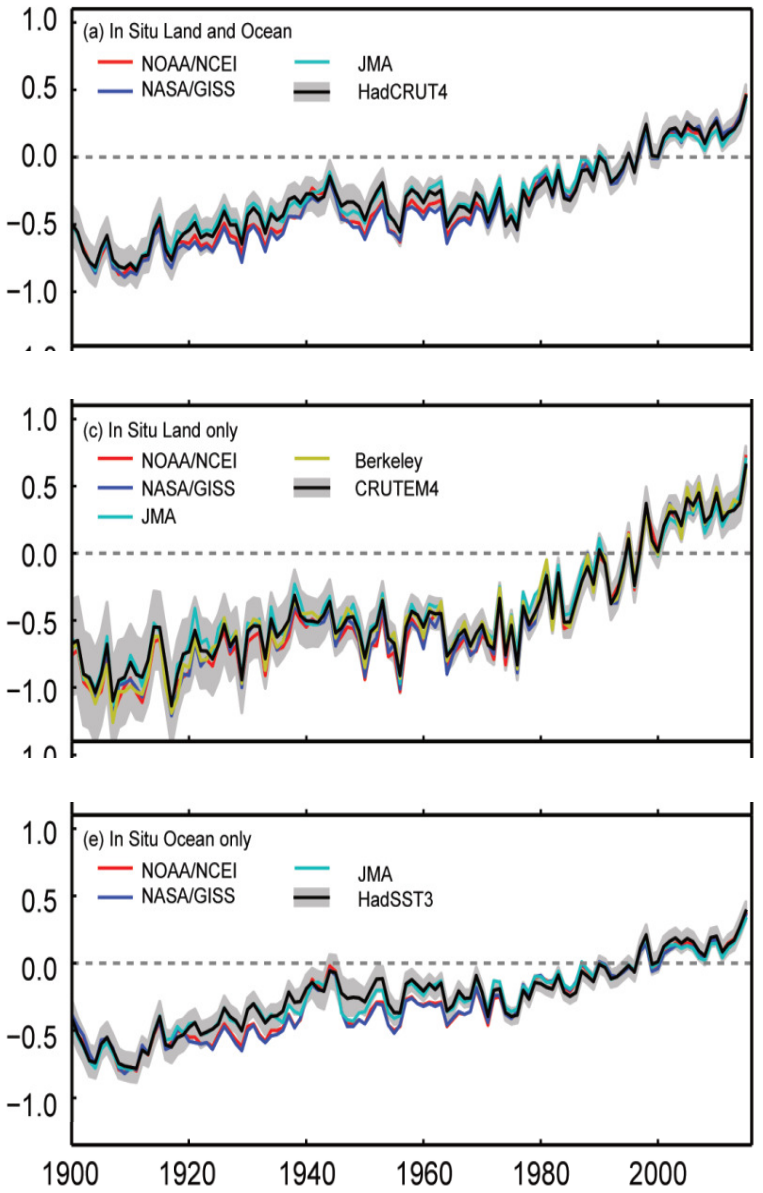
Best estimate of observed annual temperature anomalies (relative to the period 1961-1990)



Source: Kennedy et al. (Weather, August 2016)

Observed climate change

Observed temperature anomalies relative to the period 1981-2010



Land and ocean

Land only

Ocean only

Source: State of the climate (BAMS, August 2016)

Observed climate change

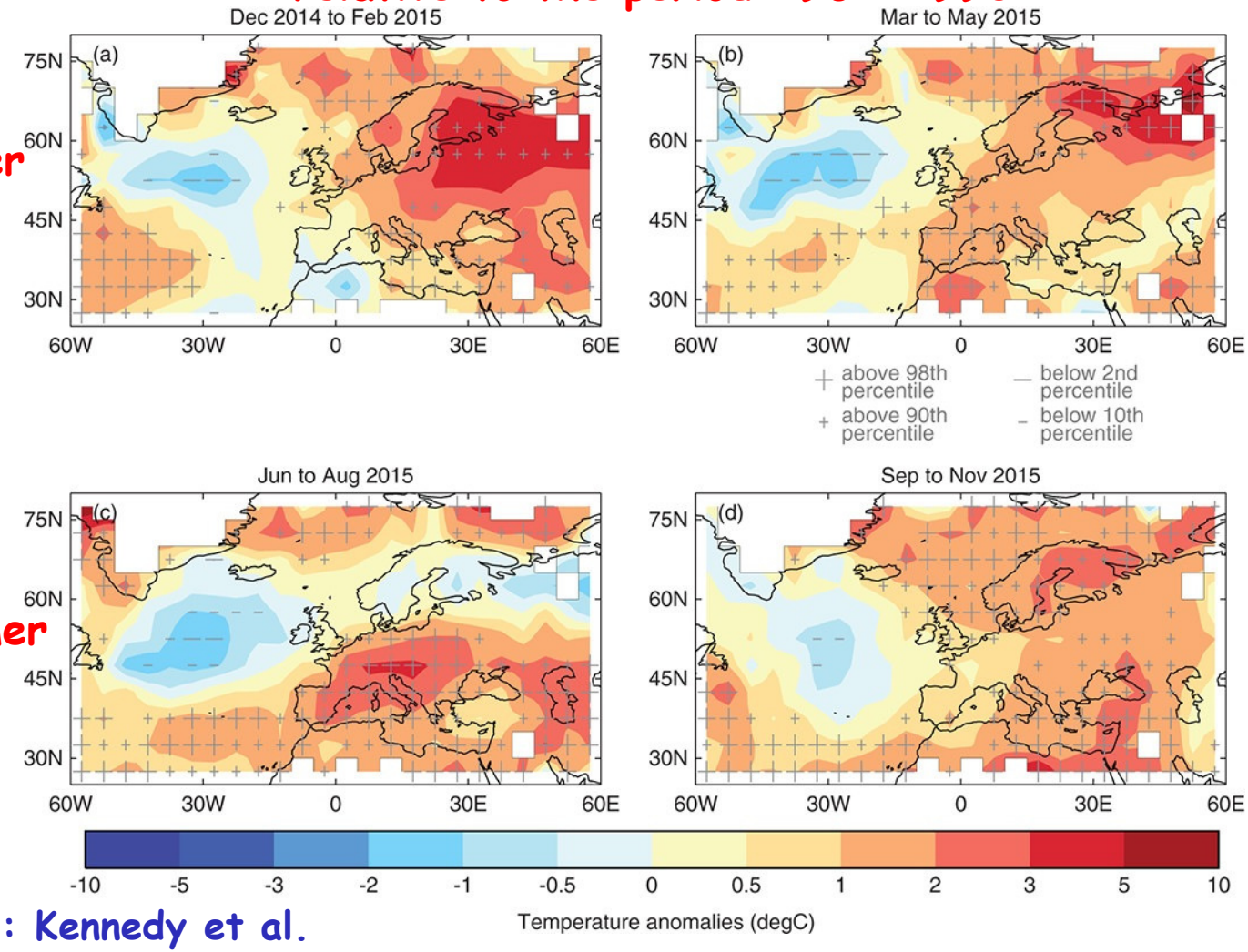
Temperature anomalies in 2015 relative to the period 1961-1990

Winter

Spring

Summer

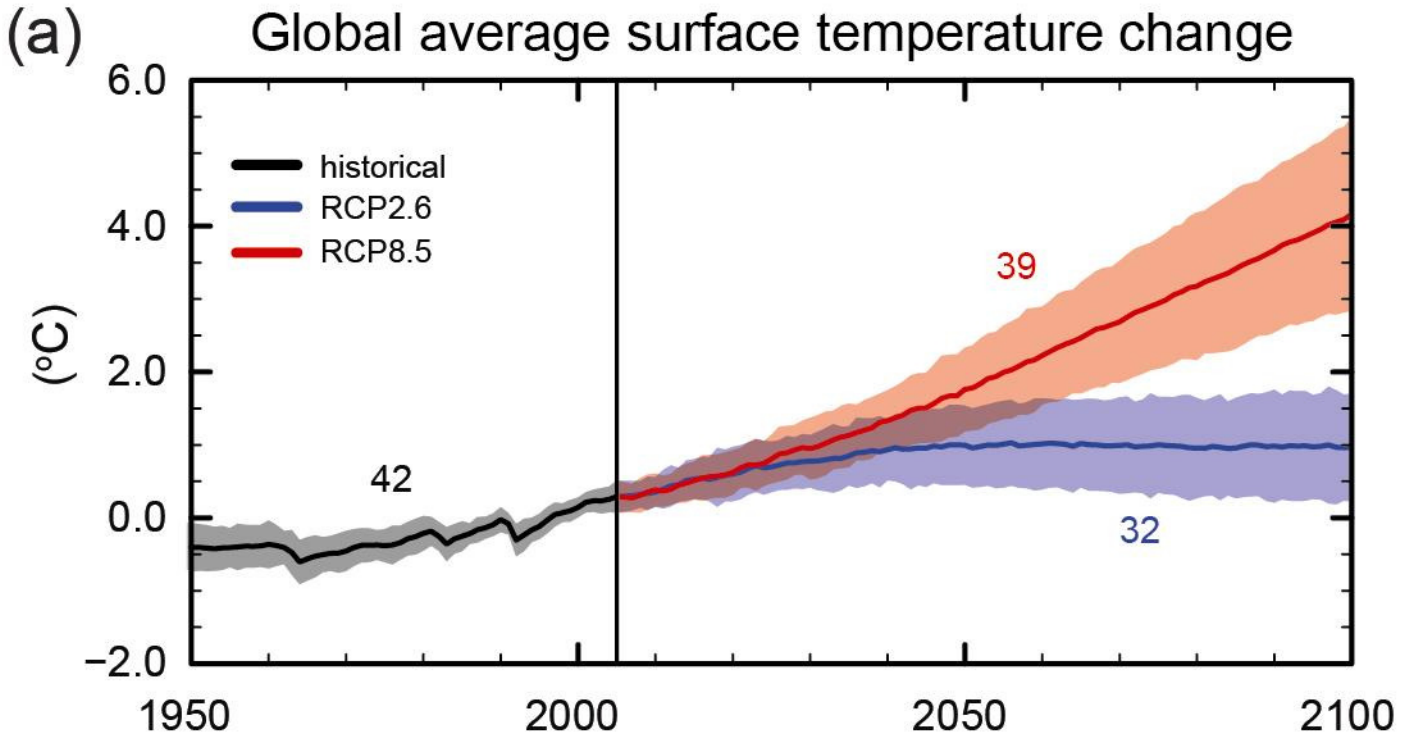
Autumn



Source: Kennedy et al. (Weather, August 2016)

Future climate change

Modelling climate change = Modelling Earth system



Source: IPCC 2013

Future climate change

* Uncertainties

Sources of uncertainities:

* Natural variablity of climate system
  * chaotic interaction among components of climate system
  * natural fluctuation can "mask" future climate changes

* Limits of scientific knowledge
  * limited understanding of climate system
  * inadequacy (imperfections) of climate models
  * uncertainties in initial conditions

* Socio-economic uncertainty
  * depends on Earth's population, industrial and technological development, ... (scenario uncertainties)

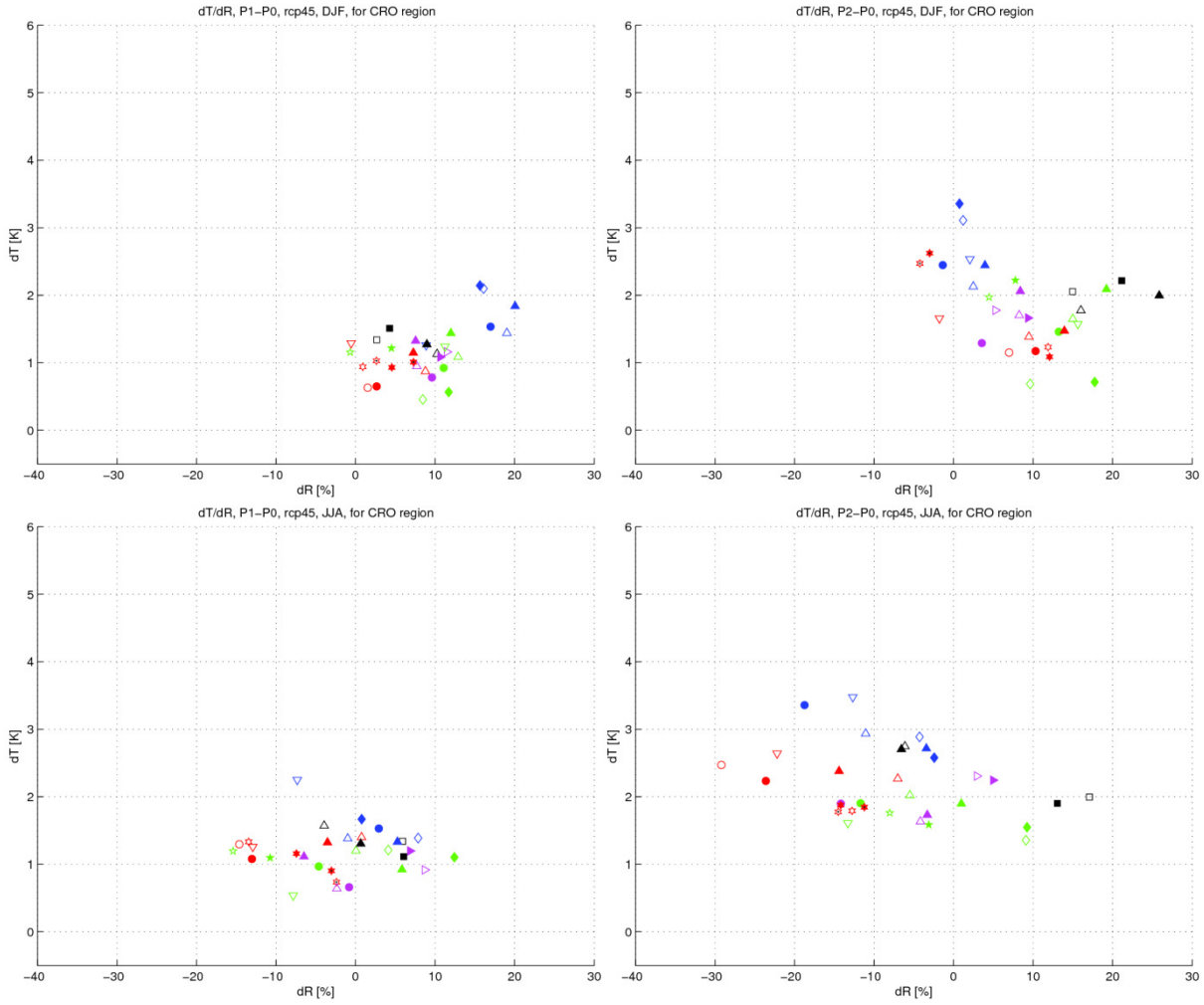
Future climate change over Croatia (I. Güttler, L. Srnec, T. Stilinović)

CORDEX + RegCM (DHMZ) simulations on VELEbit supercomputer at SRCE

P1 – P0 | P2 – P0

Winter

Summer



P0=1971-2000

P1=2011-2040

P2=2041-2070

<— change in temp —>

<— change in precip —>

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