The Abdus Salam
International Centre for Theoretical Physics

2148-14

**Fifth ICTP Workshop on the Theory and Use of Regional Climate Models**

*31 May - 11 June, 2010*

# High resolution RegCM transient simulation for the 21st century over the Alpine region using the land surface sub-grid module

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*ICTP - ESP*
*Trieste*
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# High resolution RegCM transient simulation for the 21st century over the Alpine region using the land surface sub-grid module

**E. Coppola E.I. Soon F. Giorgi**

# outline

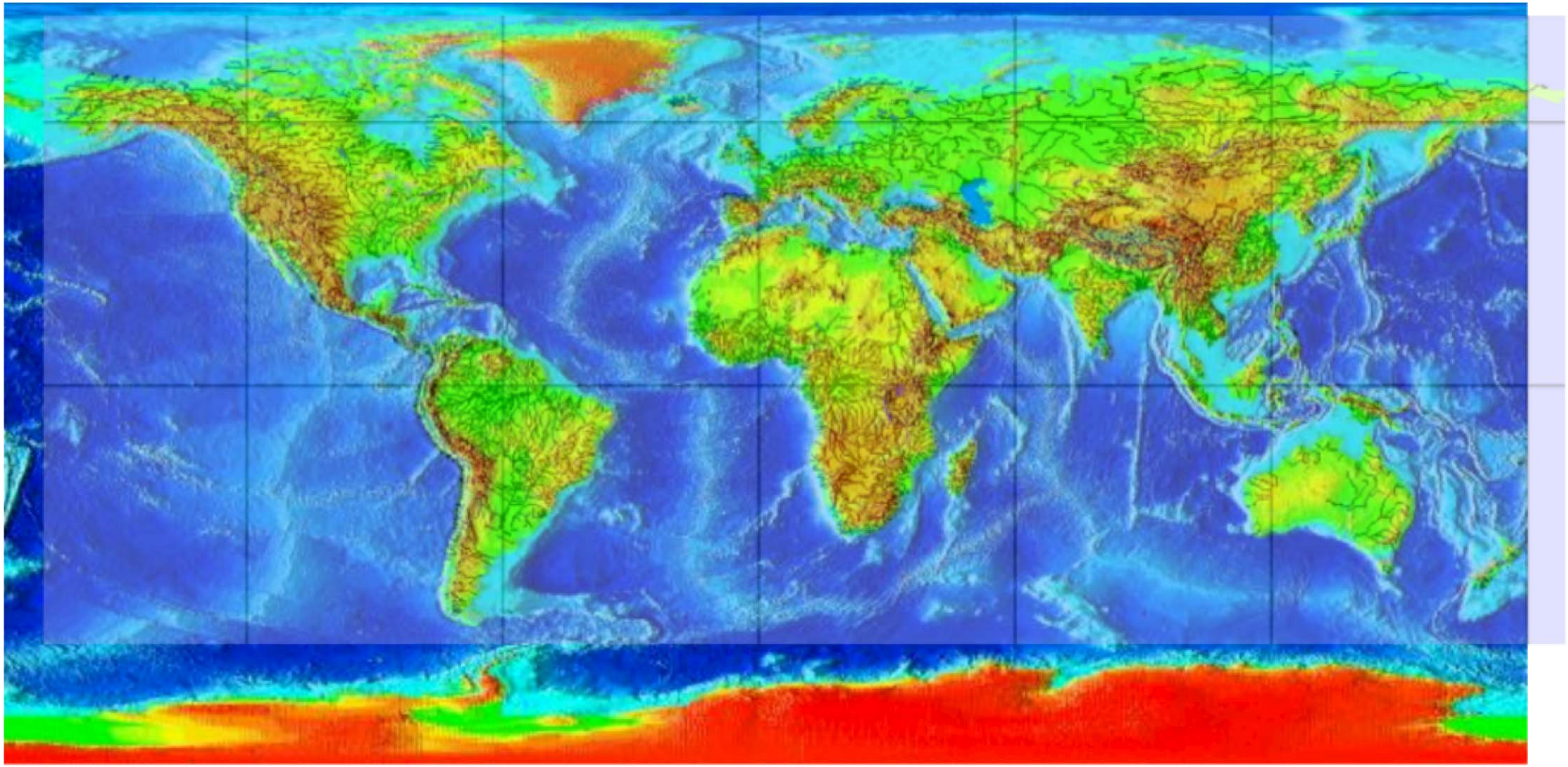
- Why Alps region – motivation and background

- Validation of the model at 3 different resolutions

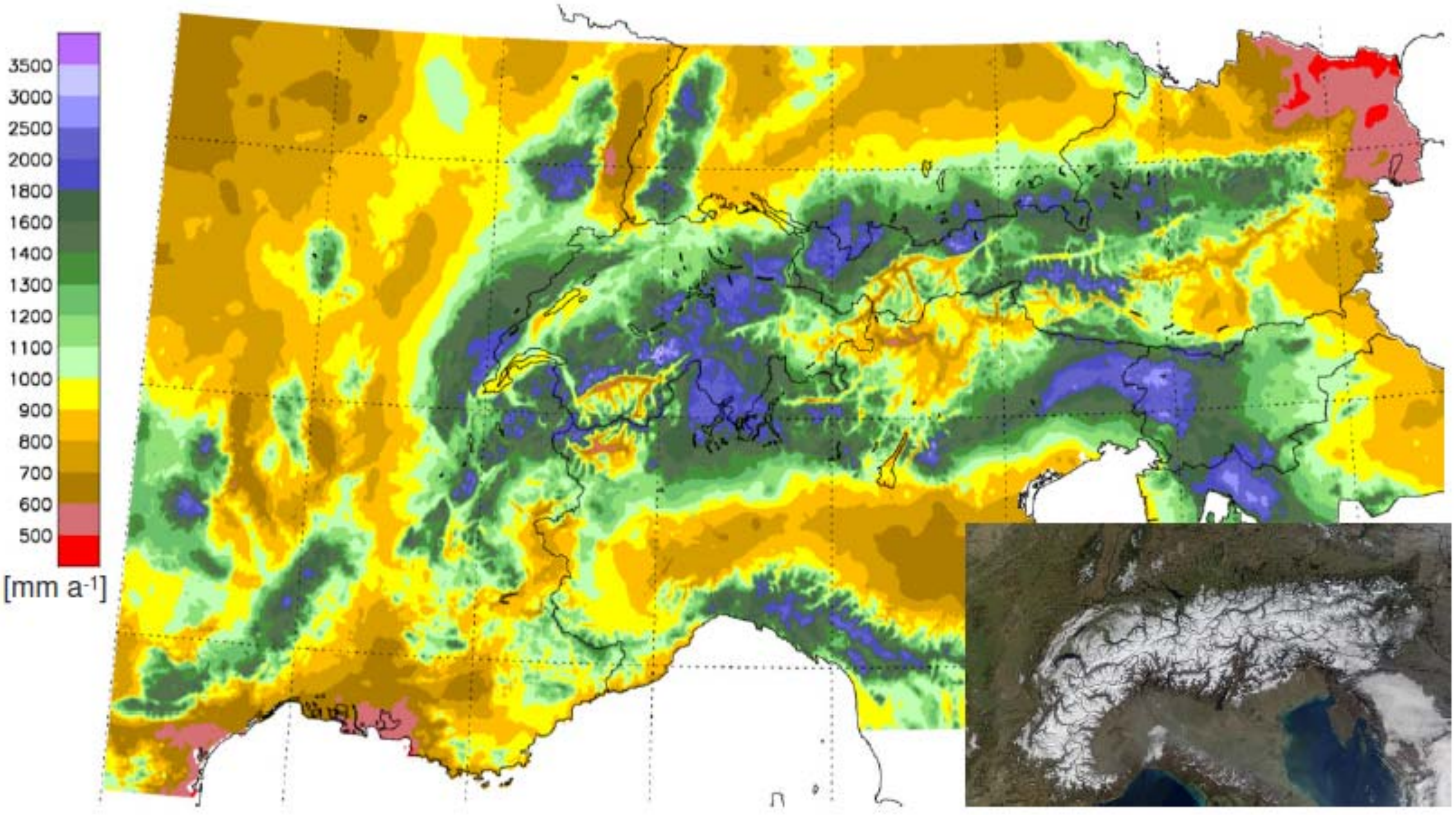
- Climate change signal dependency on the resolution

-Is the signal different increasing the model resolution?

# Mountains as a source of more than half the world’s rivers



# The Alps water tower of Europe



# What is a *water tower* ?

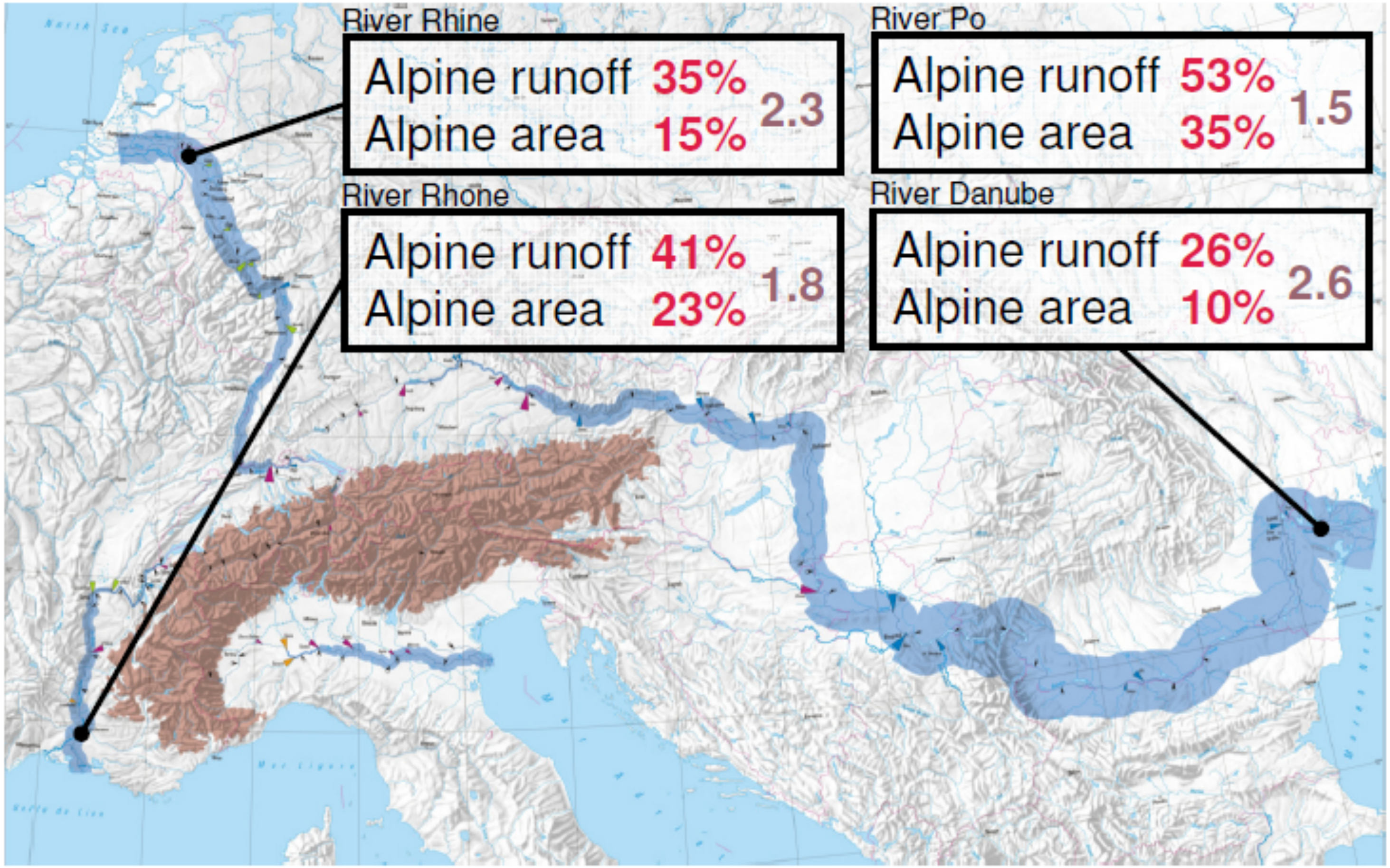
# What is a *water tower* ?

> **Superior water supply**
— higher precipitation
— lower evapotranspiration

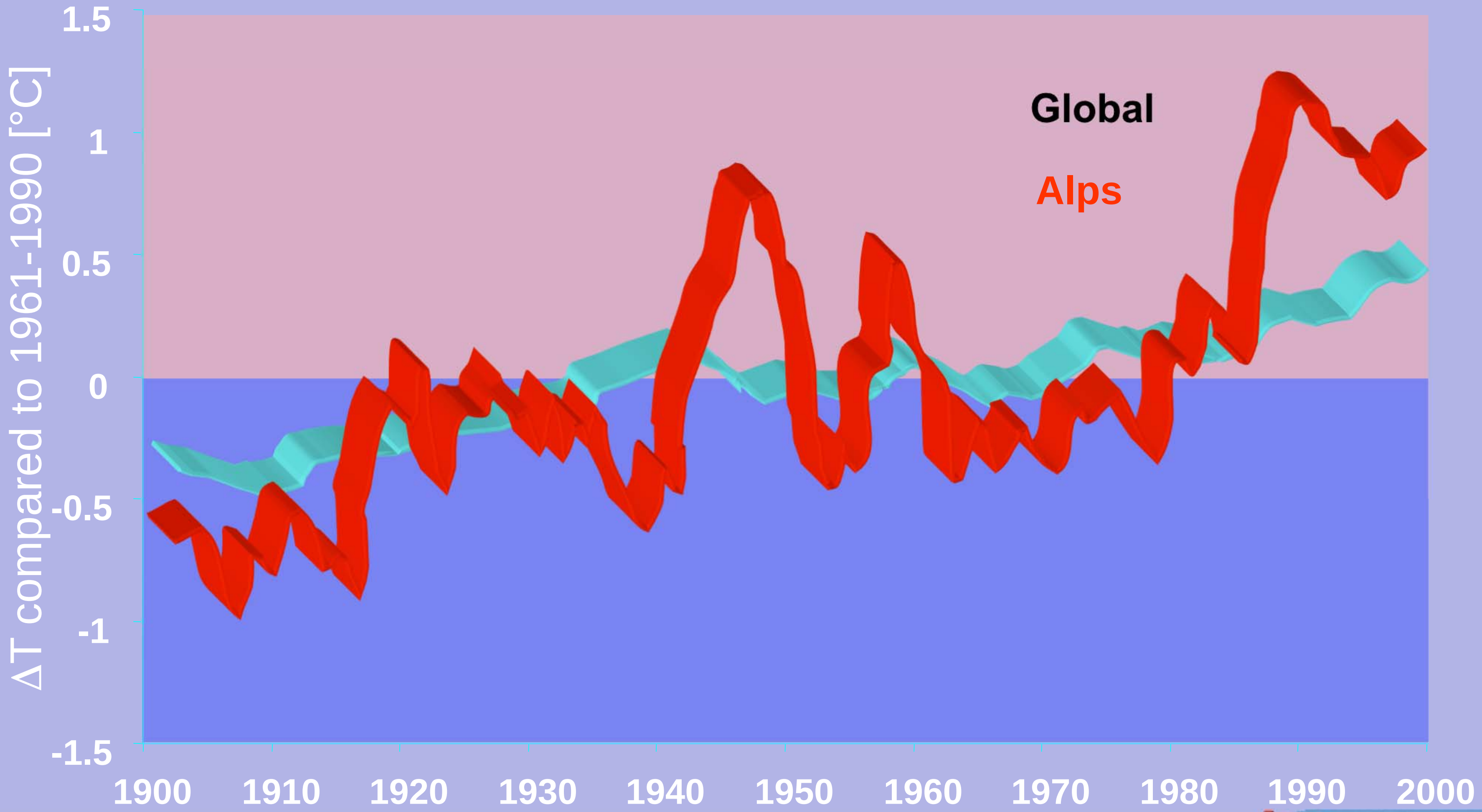
> **Seasonal redistribution of precipitation**
— snow accumulation in winter
— snow- and icemelt in spring and summer

> **Highly reliable flows arrive just in time**
— highly dependable flows from snow- and icemelt
— attenuation of downstream water deficits in summer

# The Alps water tower of Europe: the 4 major rivers

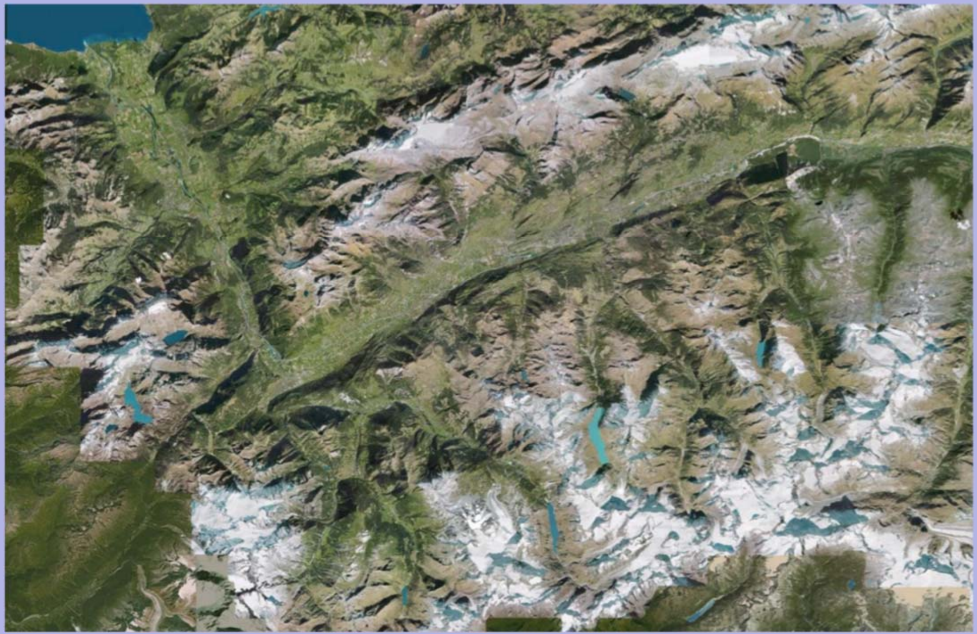


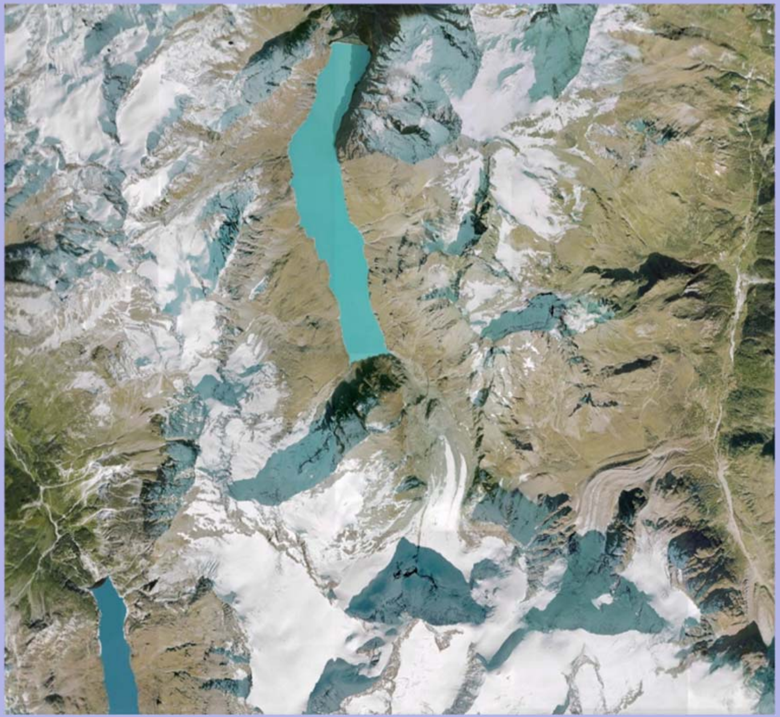
# Evolution of global and alpine temperatures, 1901-2000



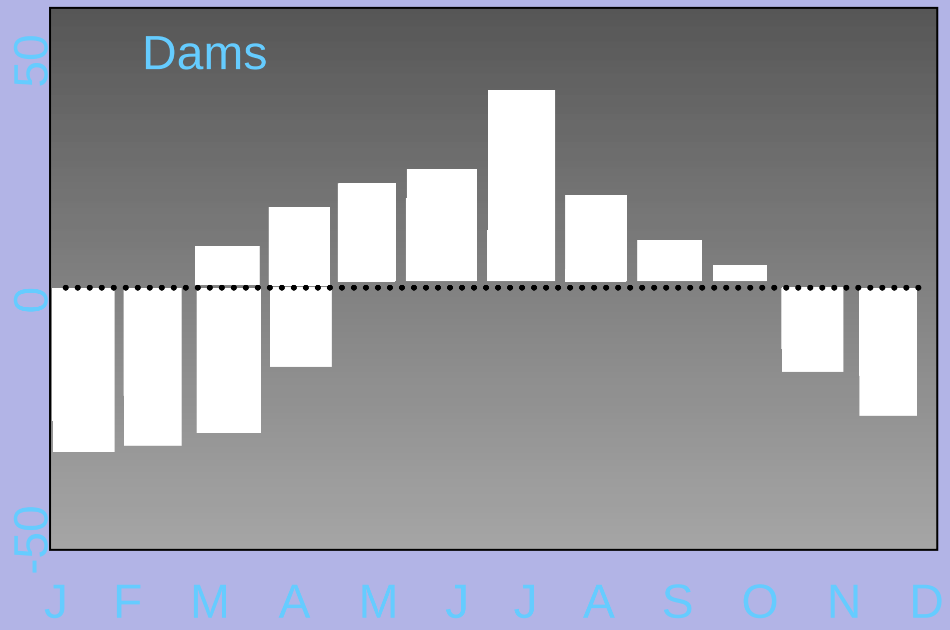

Beniston, 2000: Environmental Change in Mountains, Arnold, London

# Grande Dixence, Switzerland



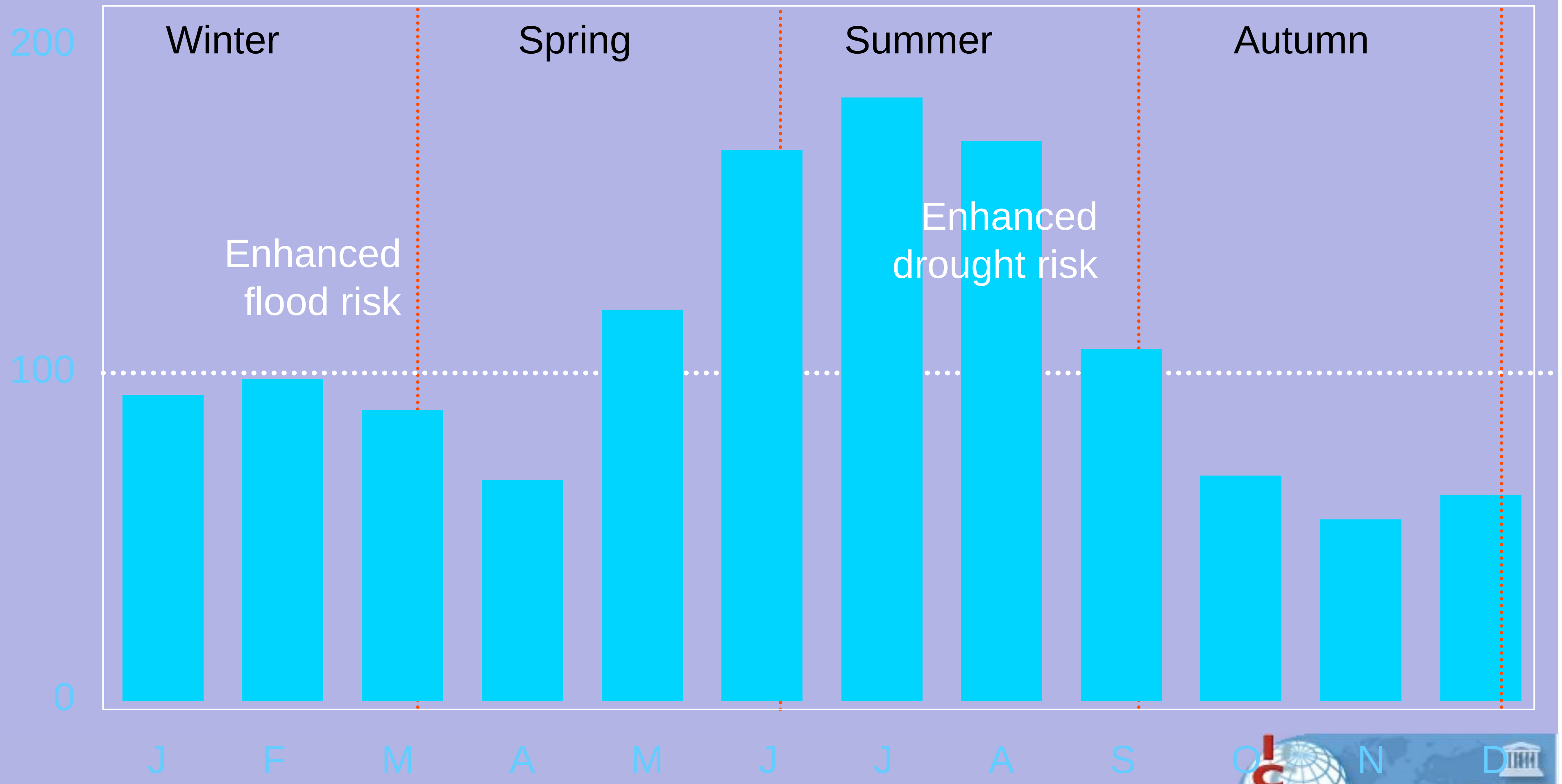


# Components of the hydrological cycle by 2100 (mm, Rhone)



# Average discharge by 2100 (mm, Rhone)

Beniston, 2004:
Climatic Change and Impacts,
Springer Publishers



**Assessing Climate change impacts on the Quantity and quality of WAter**

www.acqwa.ch


*Earth System Physics,* The Abdus Salam International Centre for Theoretical Physics

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# Experiment Design

Dynamical Downscaling♪

ECHAM5-MPI/OM A1B Global Simulation (1.8 deg)♪

RegCM3 Whole Europe A1B simulation (25km)♪

→ ENSEMBLES Project

RegCM3 SUB-BATS System (15km & 3km)\♪

→ **ACQWA Project**

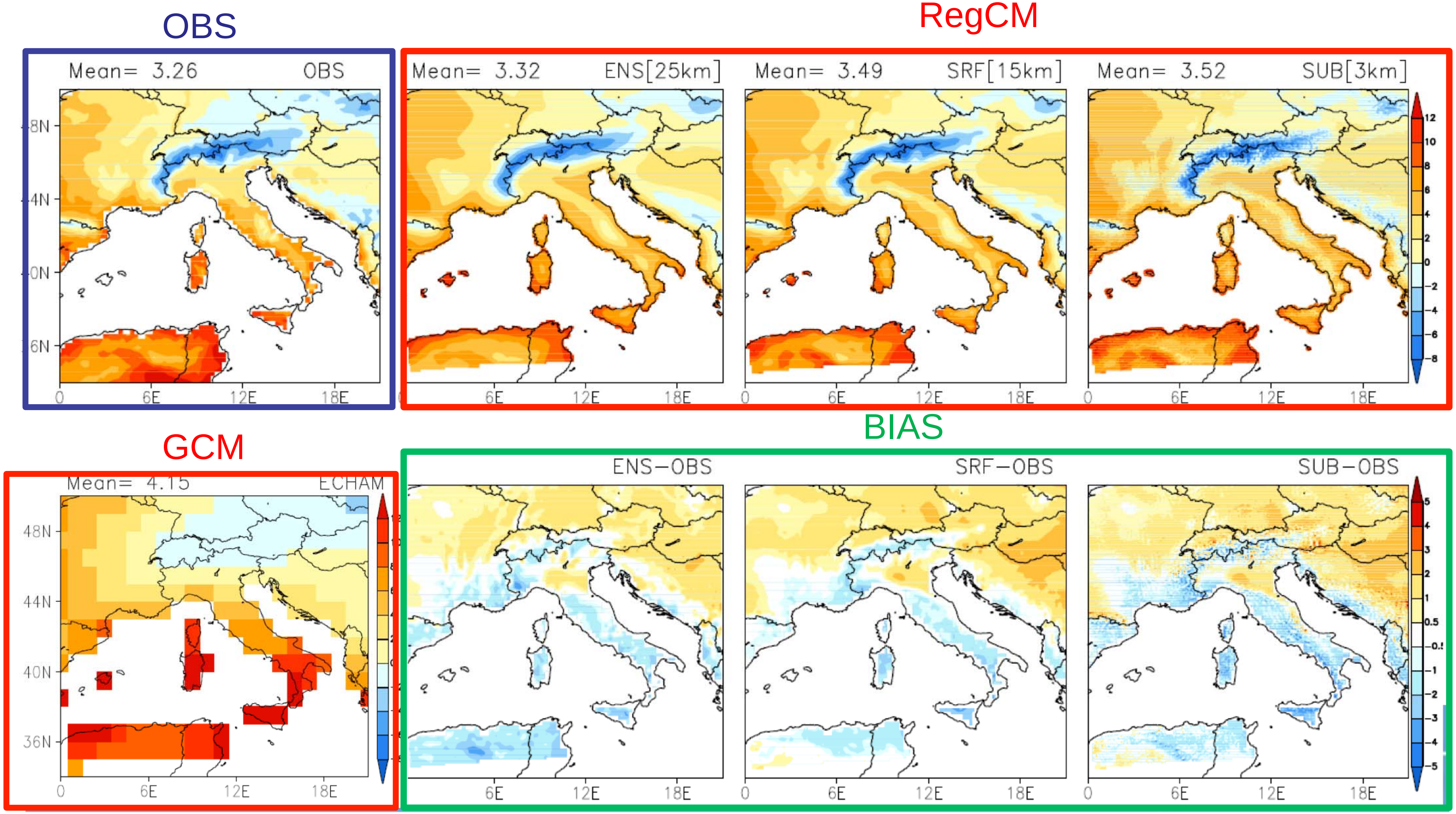
## Model Configuration

ICTP RegCM3 (Regional Climate Model Ver.3)

- Resolution: Coarse grid-15km, Subgrid-3km
- Initial & Boundary condition: ENSEMBLES 25km A1B simulation
- Integration period: 1959.1.1 – 2100.12.31 (140yr +1yr spin-up)
- Physical parameterization
  - Convection: Grell with Arakawa and Schubert closure
  - PBL: Nonlocal vertical diffusion scheme
  - Radiation: CCM3
  - Land surface scheme: BATS

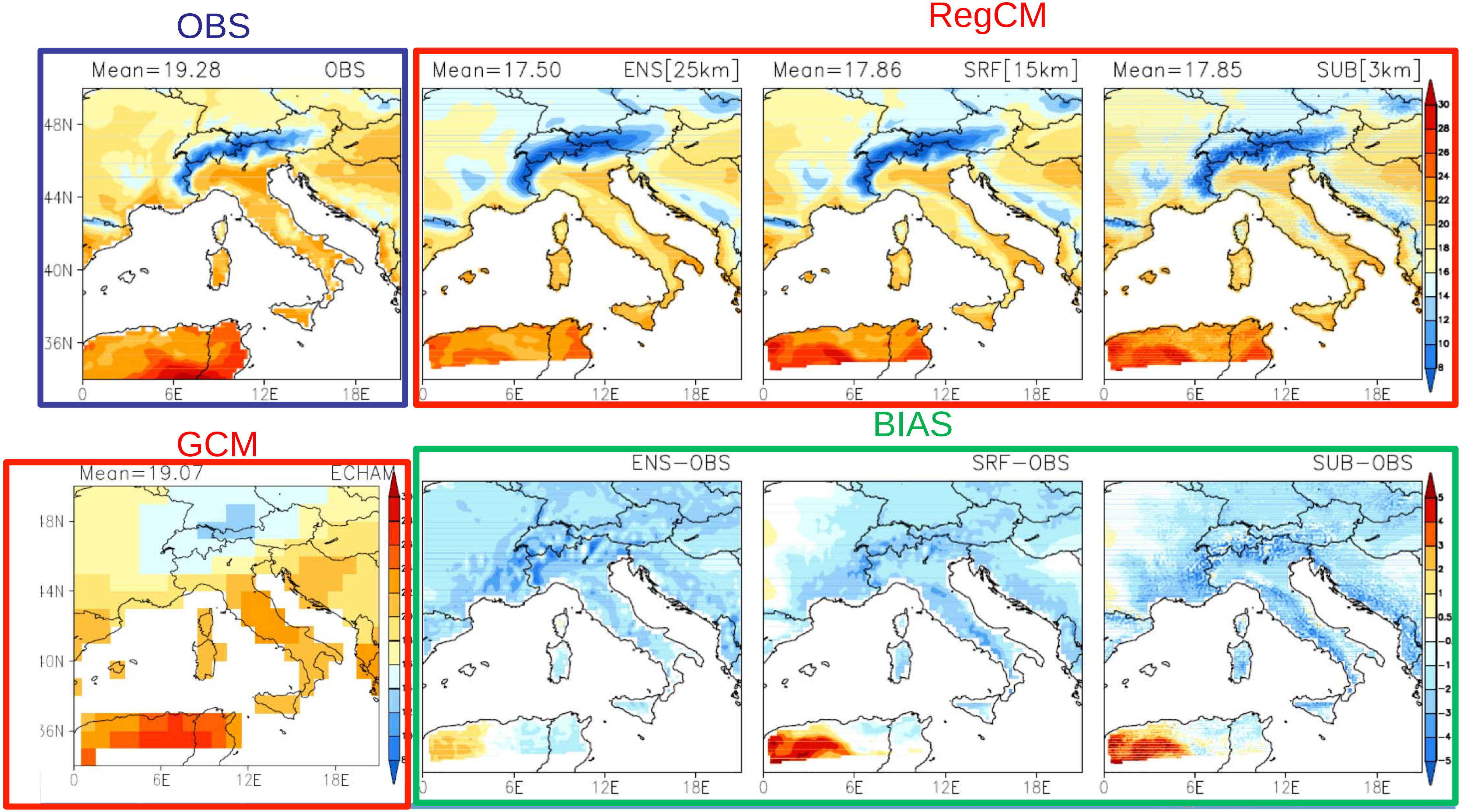
# Validation of Reference Climate (1961-2000)

## Spatial distribution of seasonal mean (DJF) surface air temperature over the whole domain



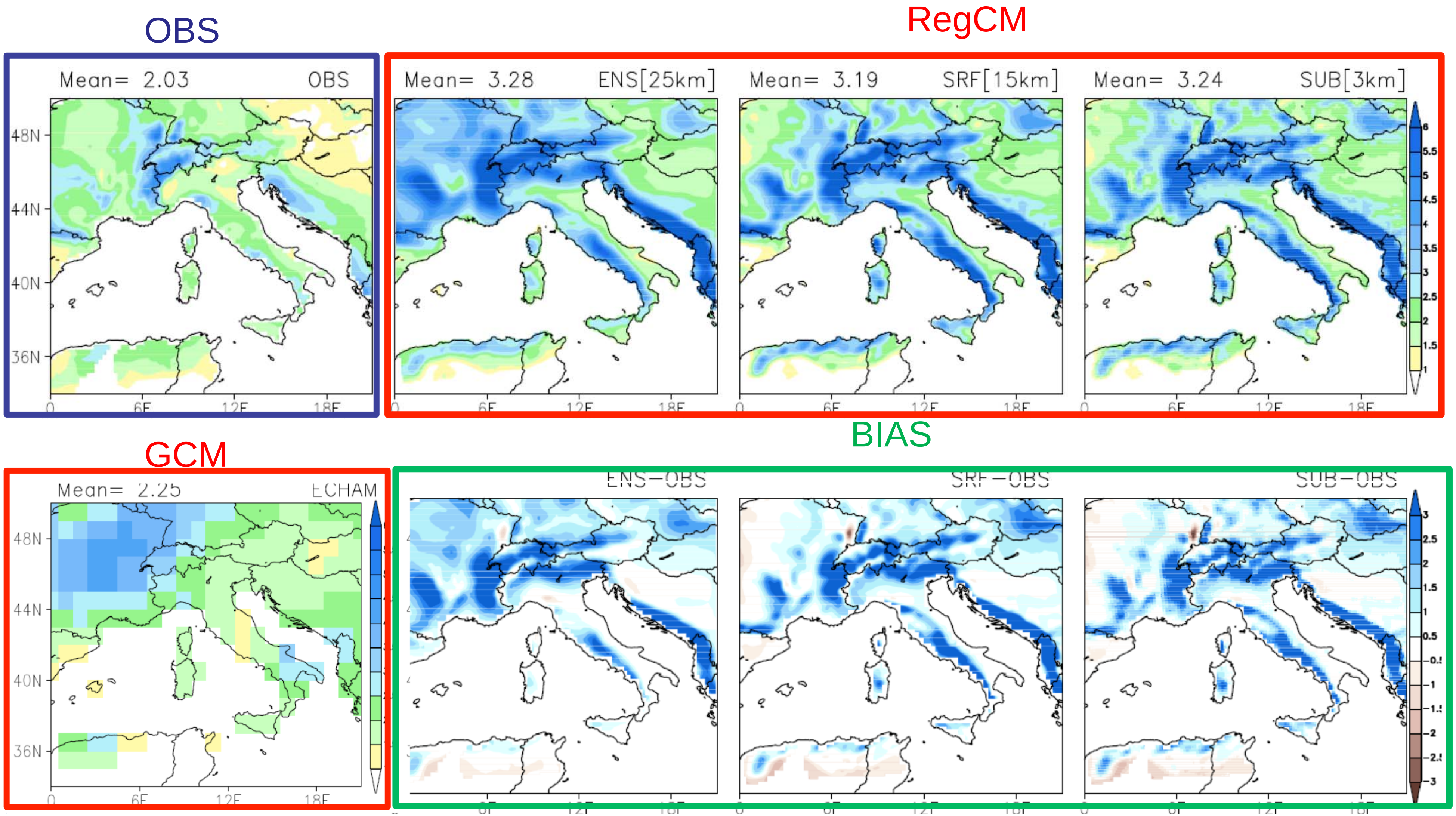
# Validation of Reference Climate (1961-2000)

## Spatial distribution of seasonal mean (JJA) surface air temperature over the whole domain



# Validation of Reference Climate (1961-2000)

**Spatial distribution of seasonal mean (DJF) precipitation over the whole domain**



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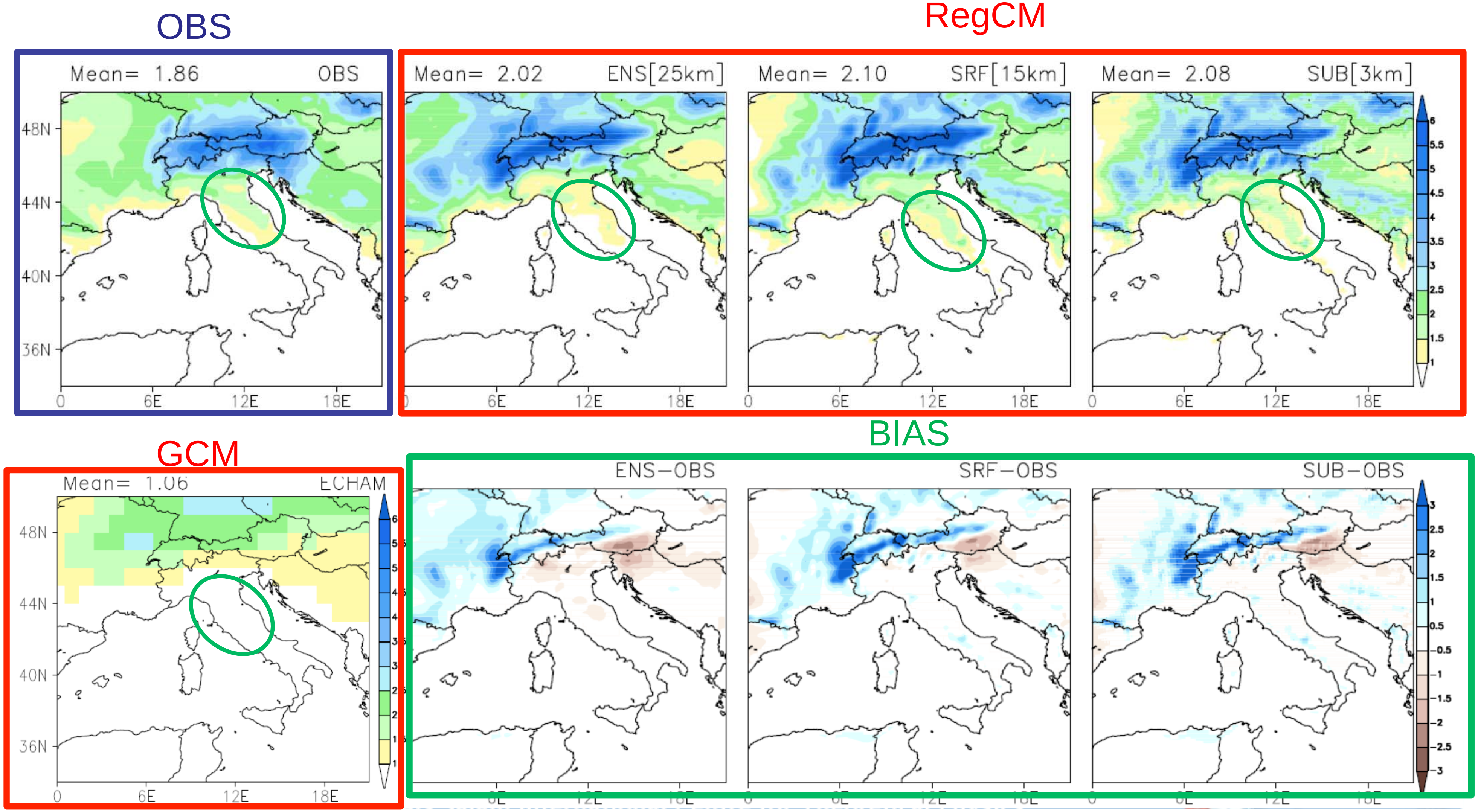
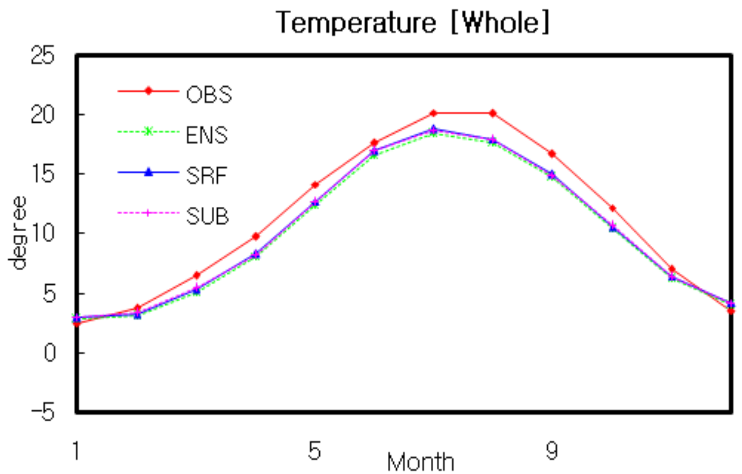
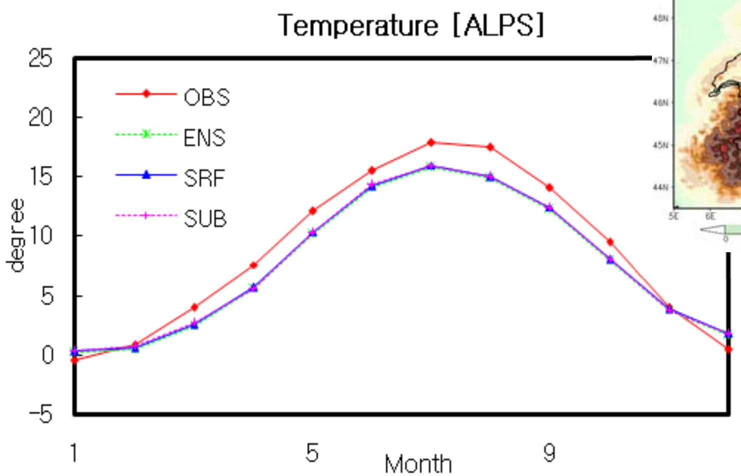
**Spatial distribution of seasonal mean (JJA) precipitation over the whole domain**

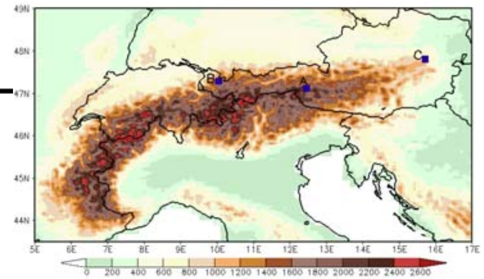


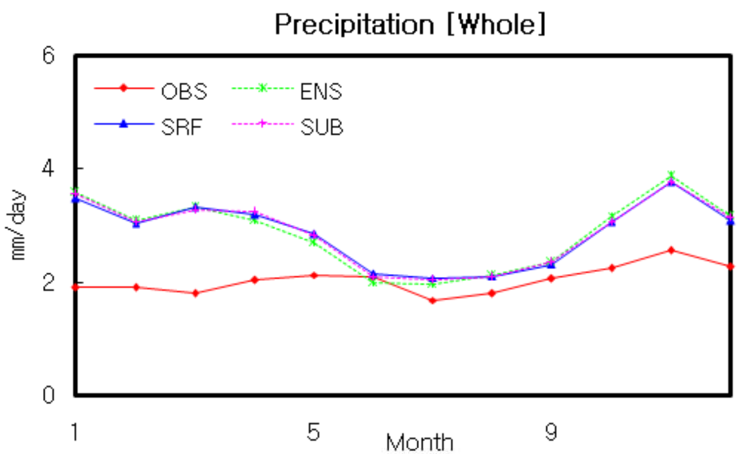
# Validation of Reference Climate (1961-2000)

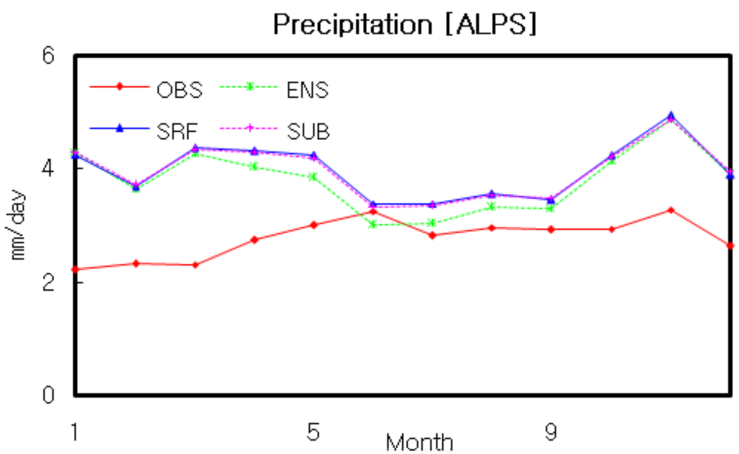
**Seasonal variation (40yr mean) of temperature and precipitation over the whole domain (Lon: 0-21E, Lat: 34-50N) and Alps region (Lon:5-17E, Lat: 43.5-49N) from OBS, ENS (25km), SRF(15km) and SUB(3km) simulations.**



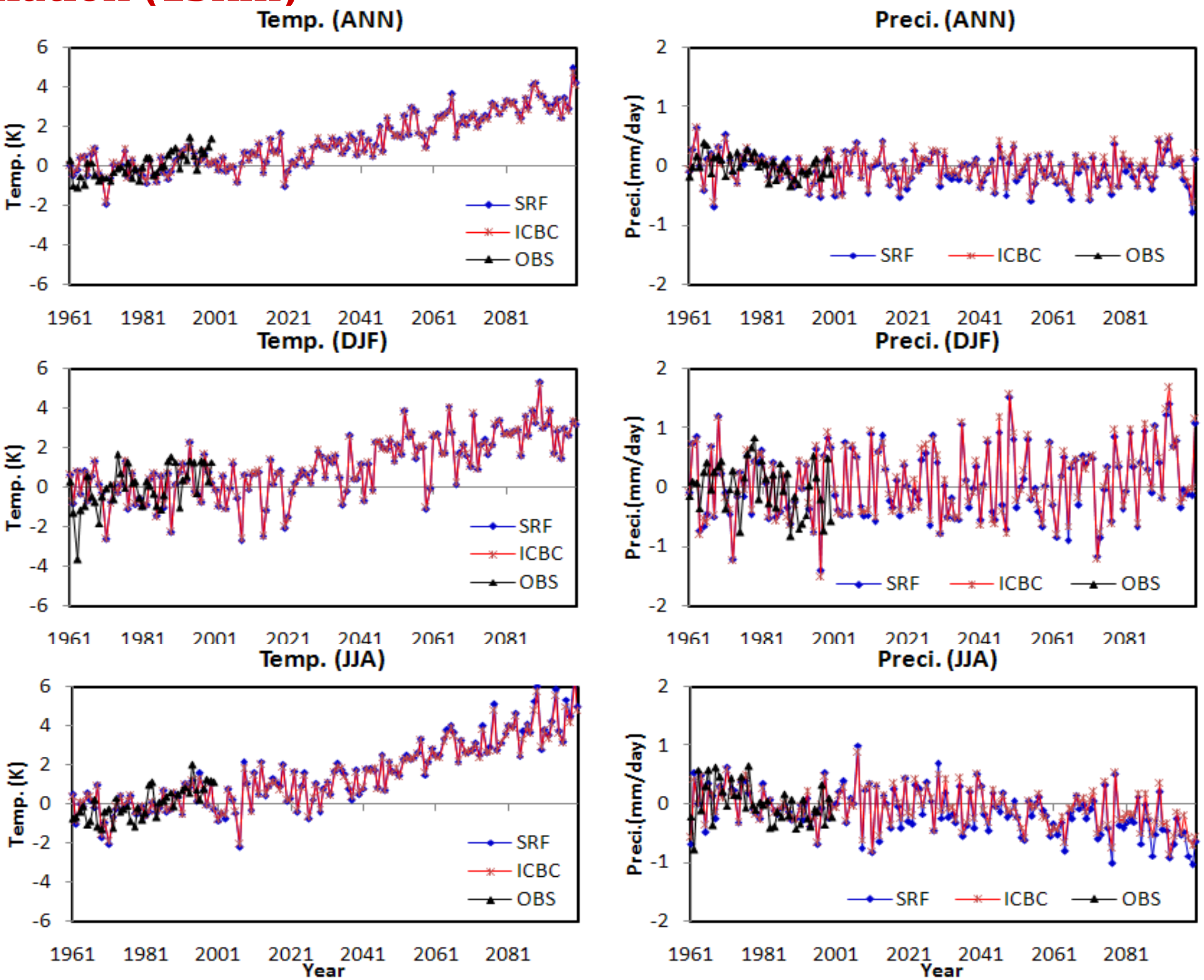





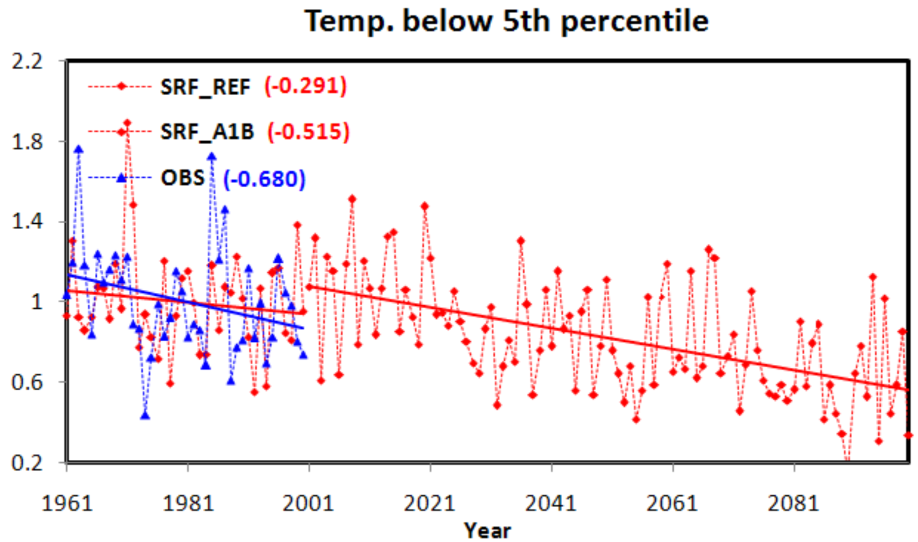
# Validation of Reference Climate (1961-2000)

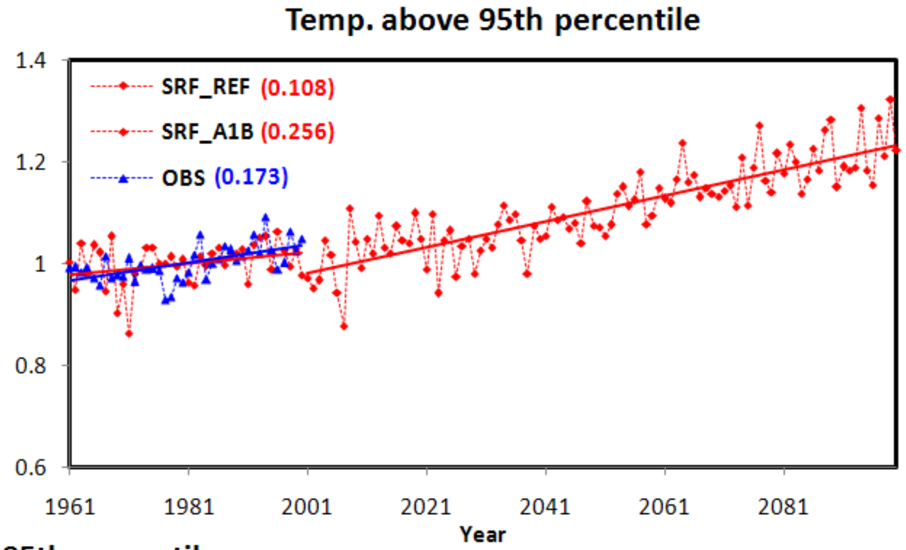
**Temporal evolution temperature and precipitation anomalies over whole domain (Lon: 0-21E, Lat: 34-50N) for observation, ICBC (25km), and SRF simulation (15km)**

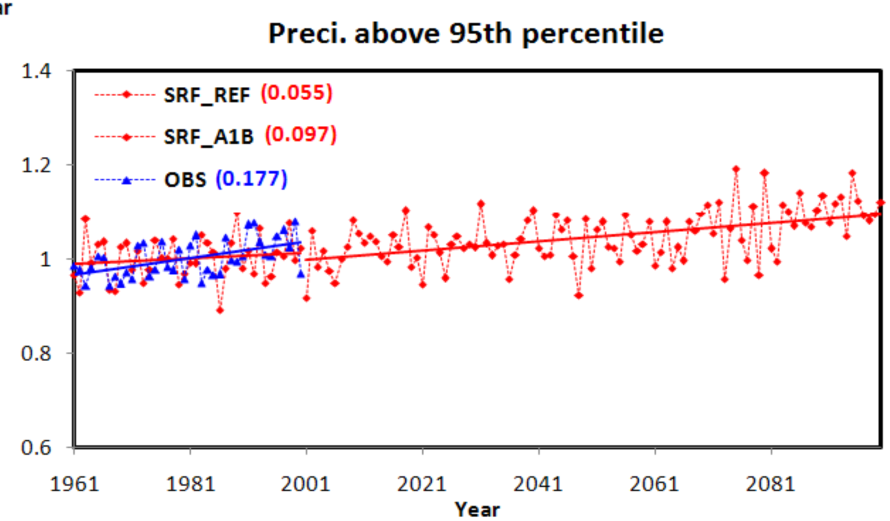


# Validation of Reference Climate (1961-2000)

**Time series of area-averaged normalized temperature below 5$^{th}$ percentile and above 95$^{th}$ percentile, and precipitation above 95$^{th}$ percentile over whole domain**



# outline

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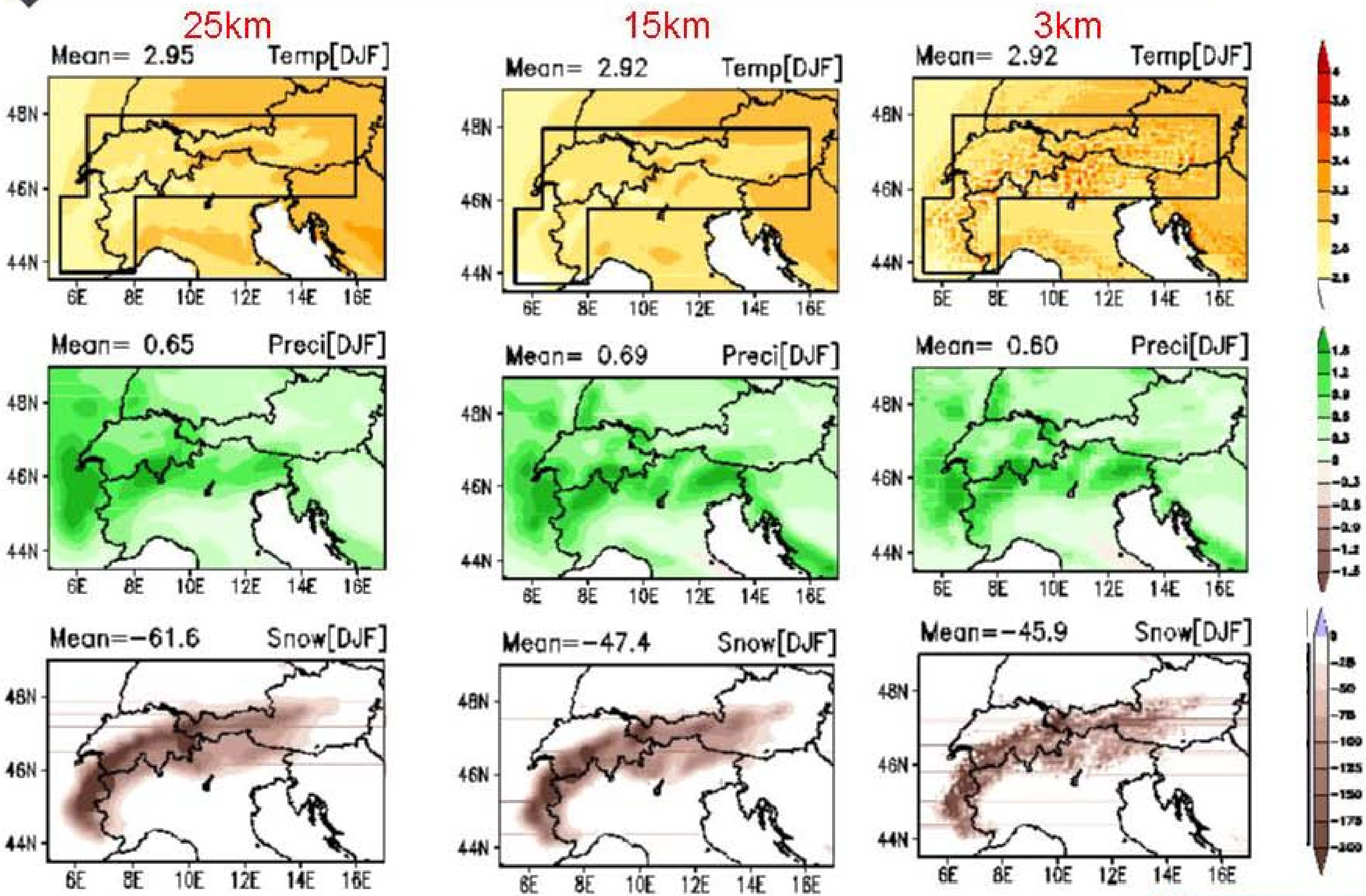
# Future Climate Change [2071-2100]-[1971-2000]



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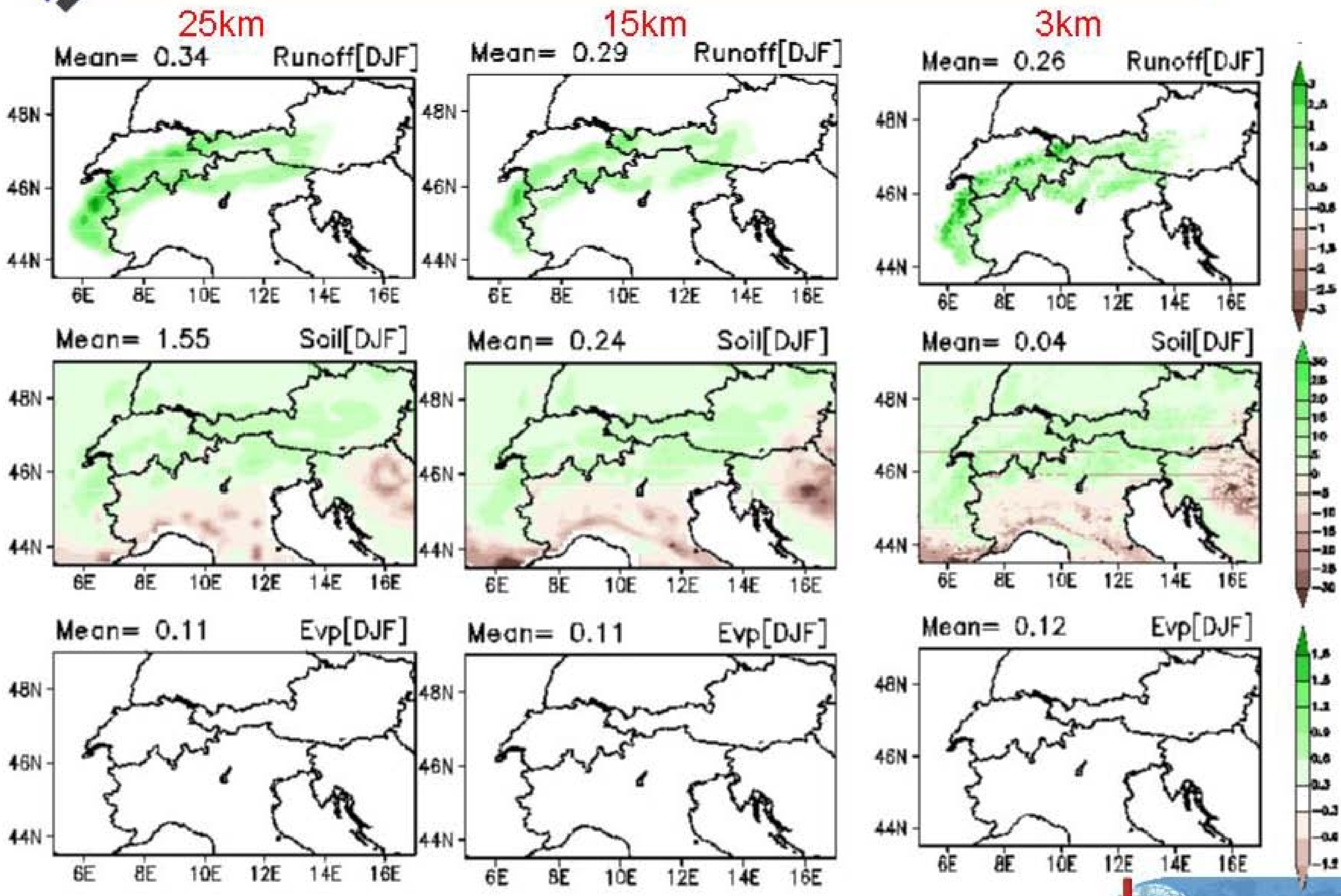

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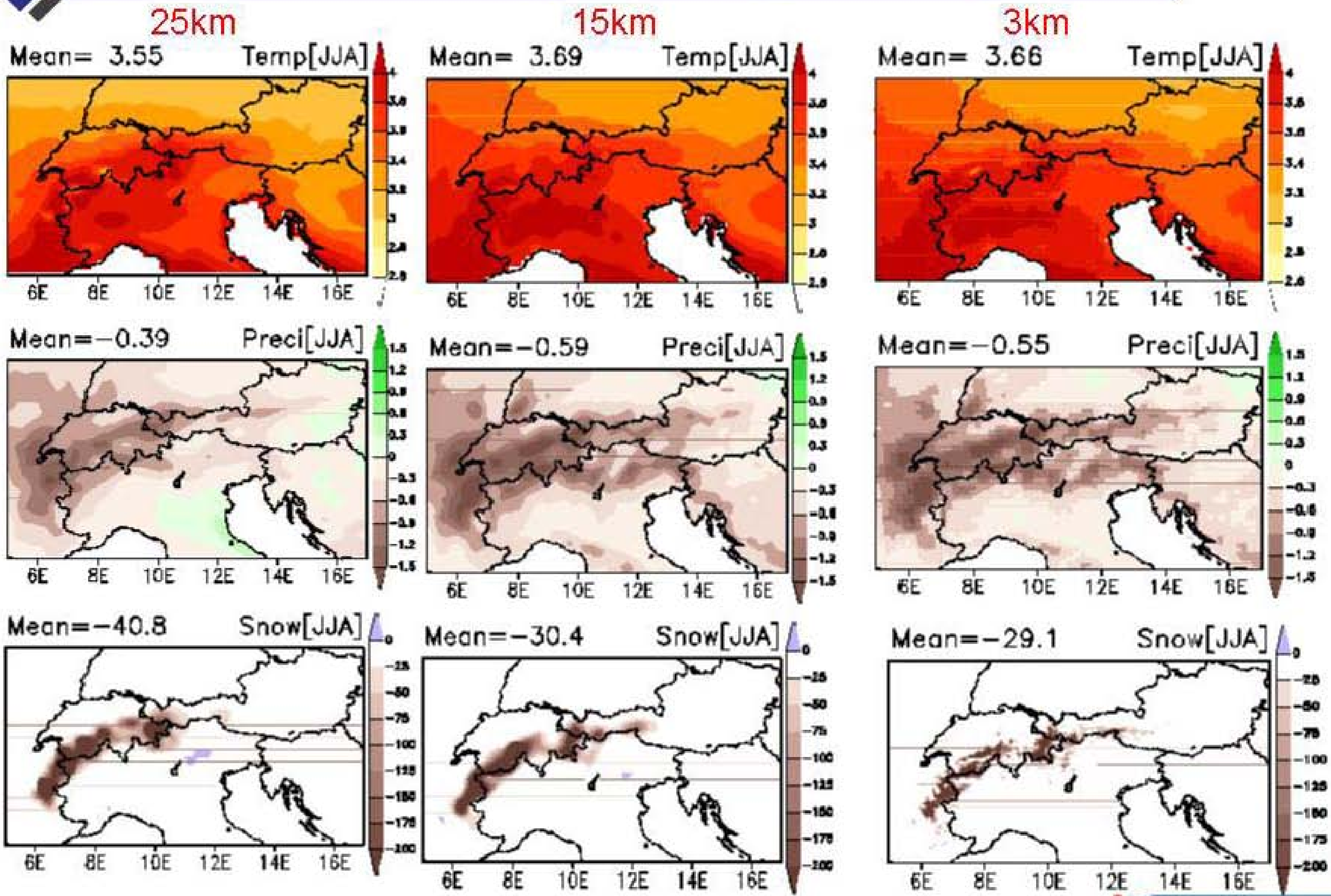
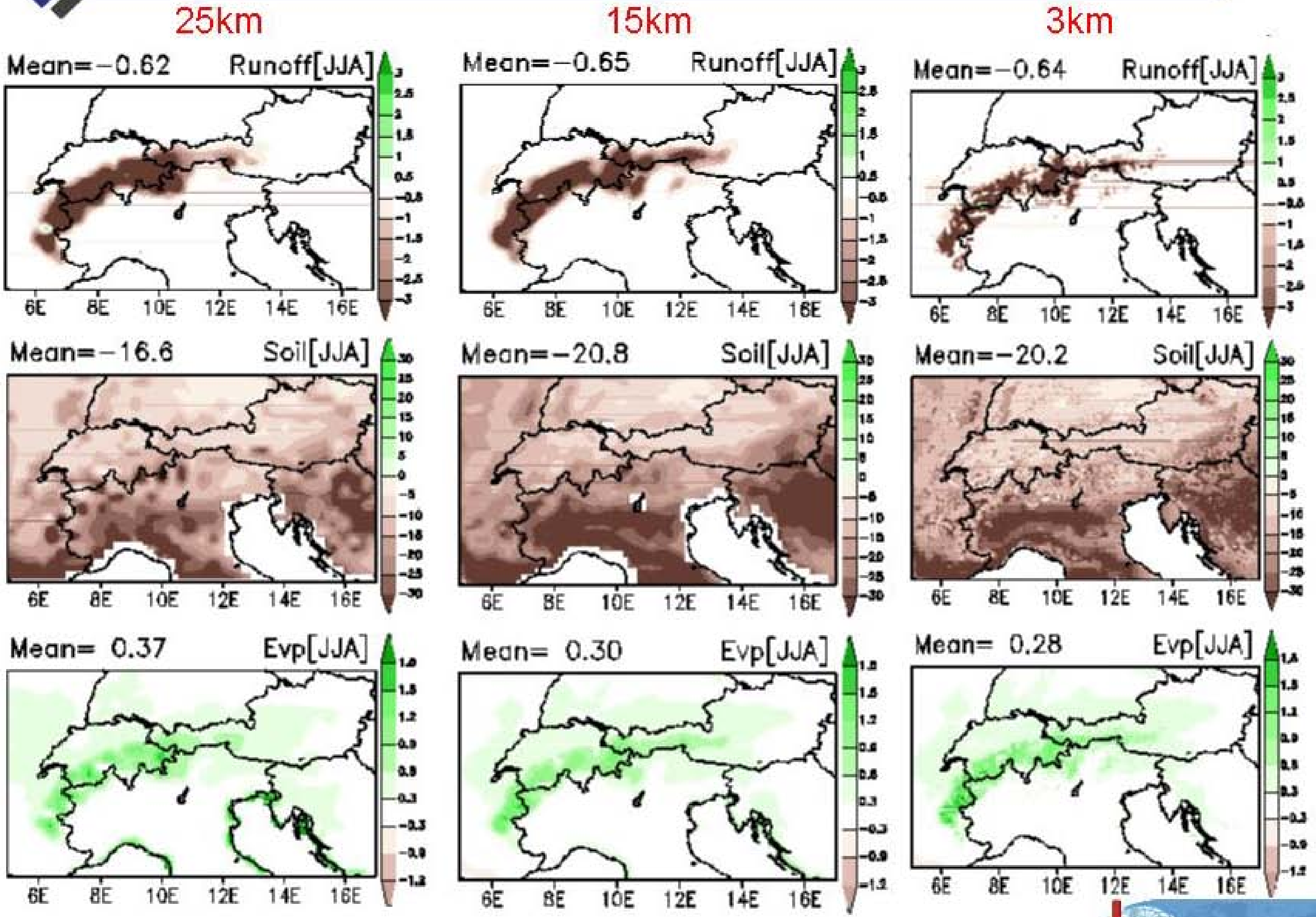
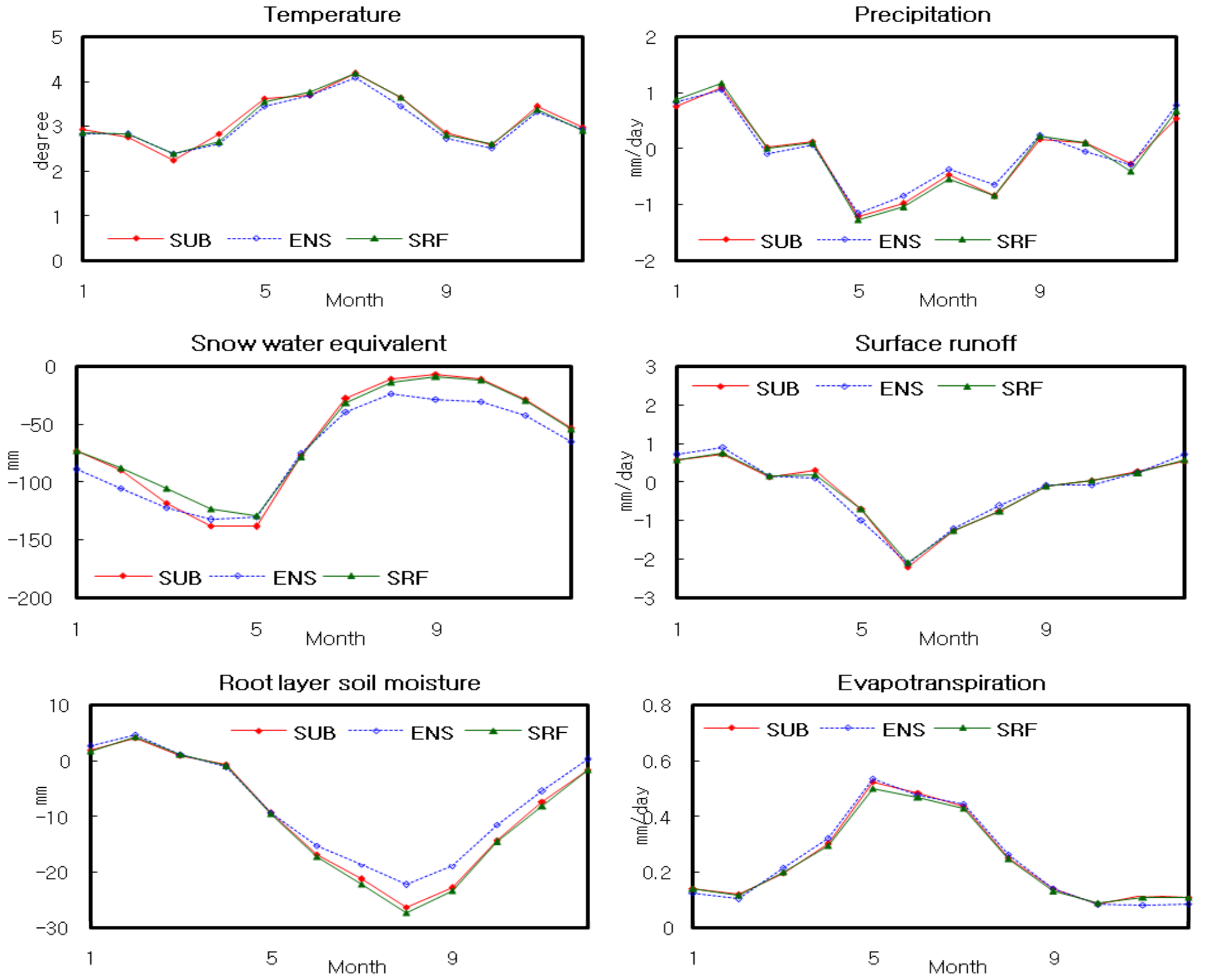


# Future Climate Change [2071-2100]-[1971-2000]



# Future Climate Change [2071-2100]-[1971-2000]

**Future changes in temp, preci, snow, runoff, soil moisture, and evap in ENS 25km, SRF 15km and SUB 3km simulations over Alps**



# Conclusion up to this point

•The seasonal climate change signal maps do show some differences depending on the resolution

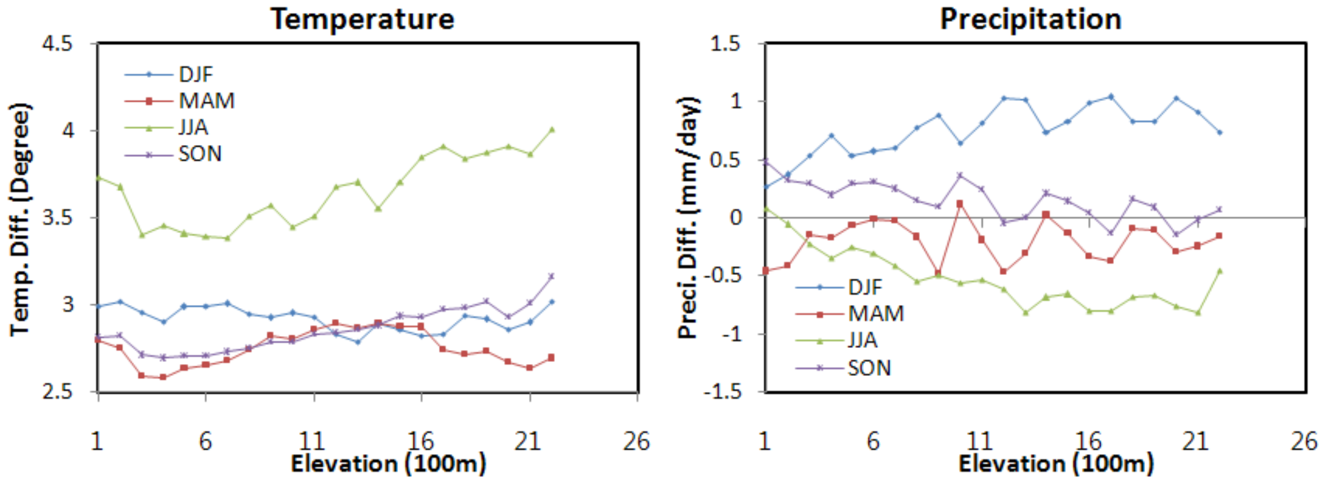
•If we do examine the yearly cycle of the precipitation, as well as other components of the surface energy and water budgets averaged over the alps domain the differences are small

•What can we get if we look at the change signal as a function of the elevation?

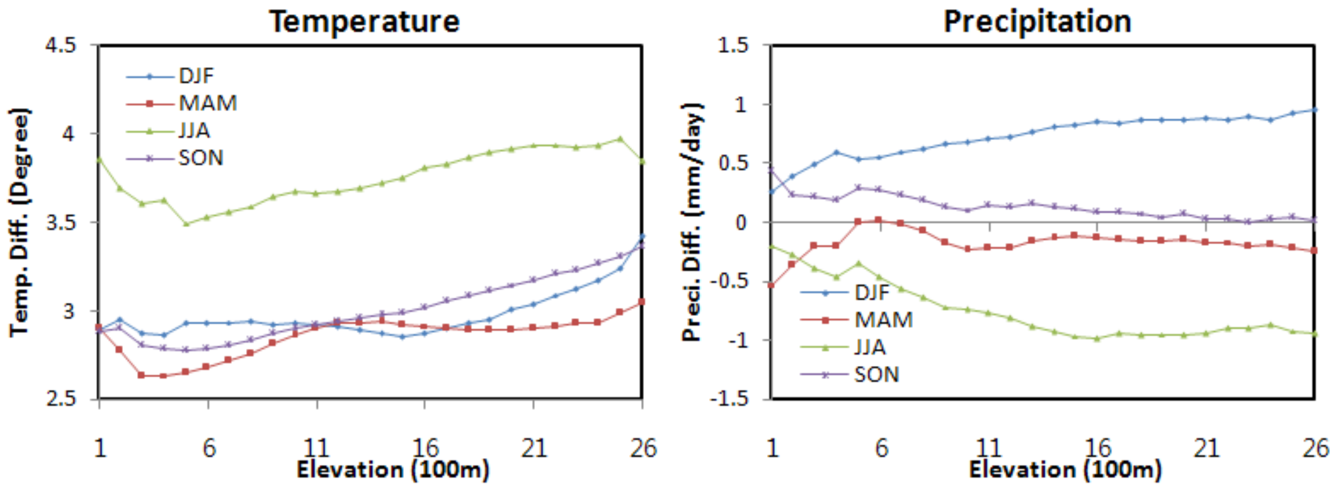
# Future Climate Change [2071-2100]-[1971-2000]

## Future change in temperature and precipitation as a function of elevation for the four seasons

**ENS 25km**

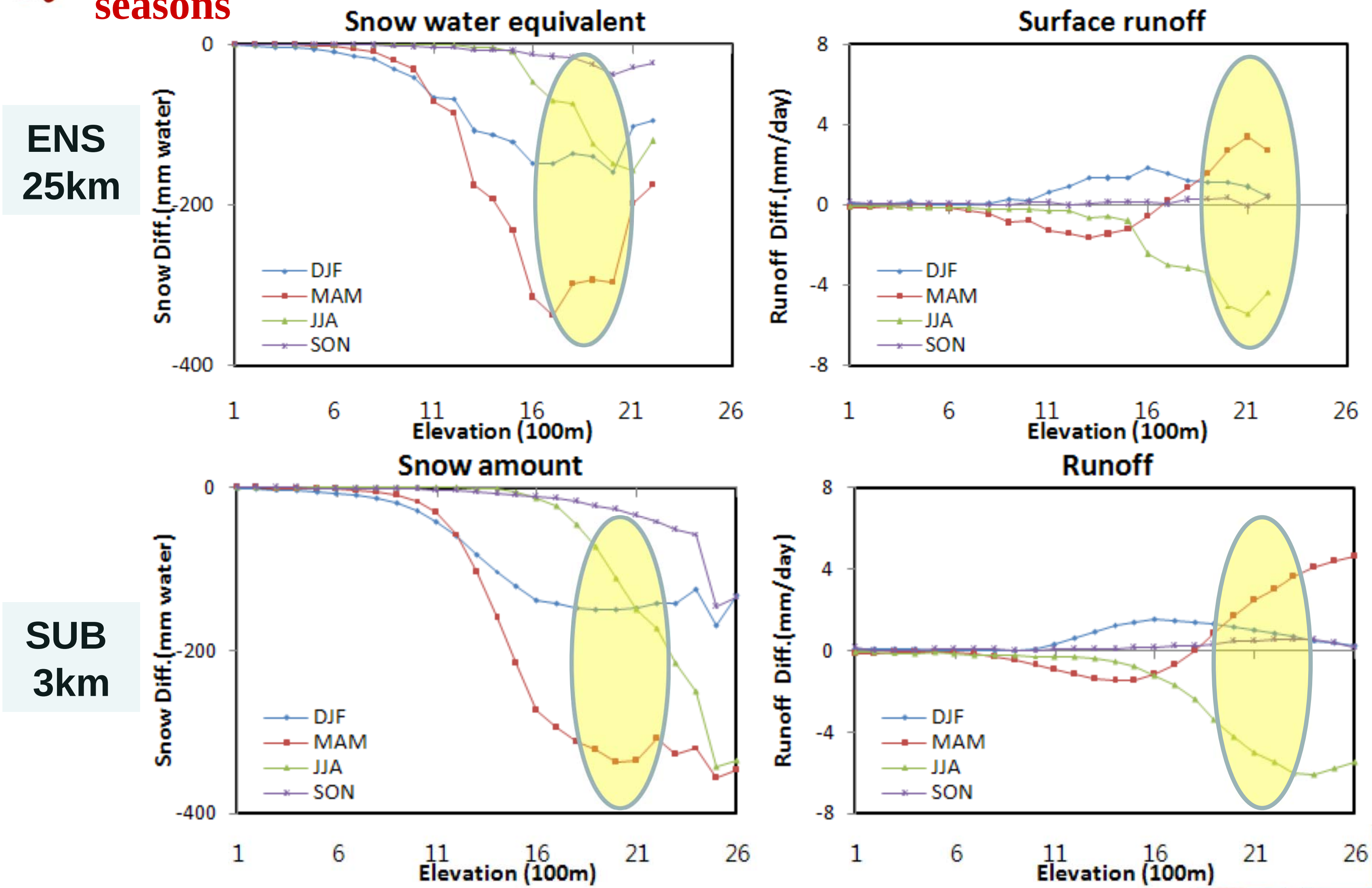



**SUB 3km**

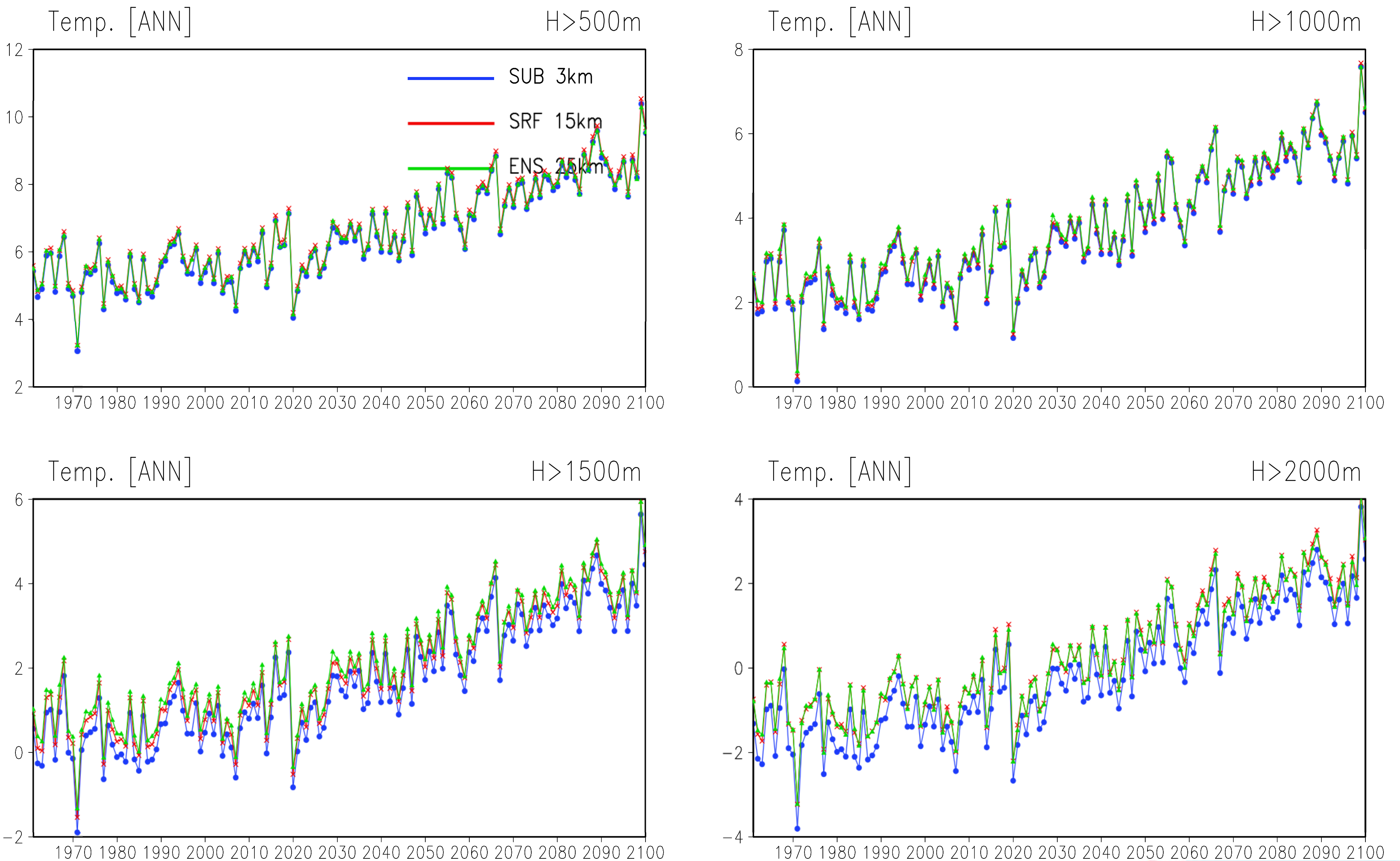


# Future Climate Change [2071-2100]-[1971-2000]

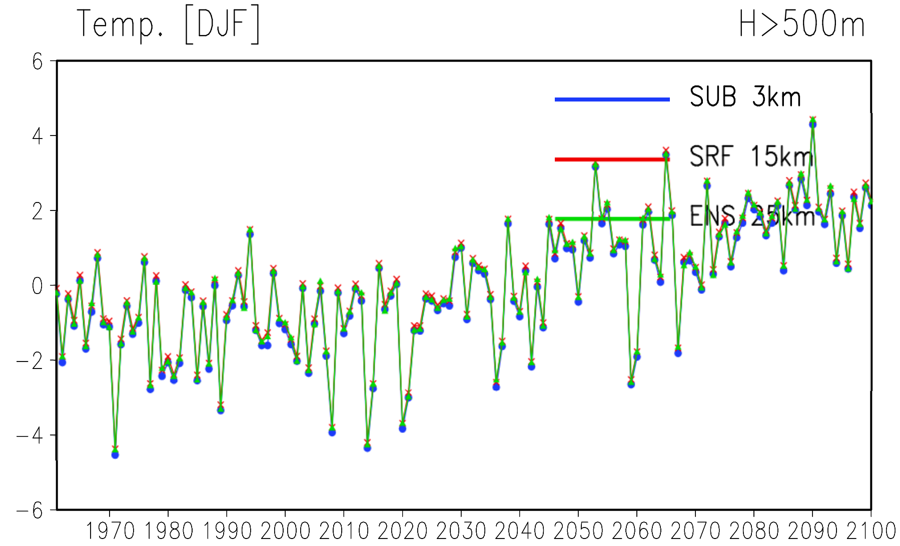
## Future change in snow and runoff as a function of elevation for the four seasons

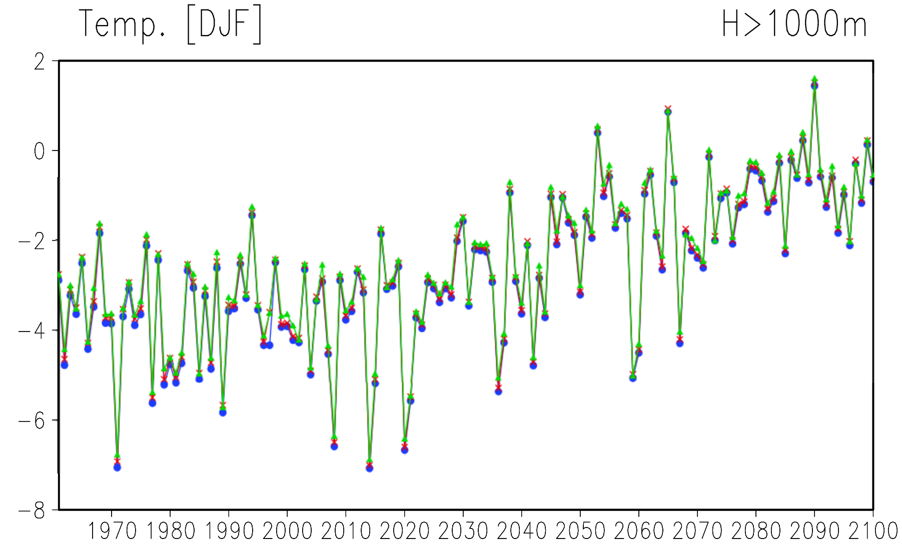


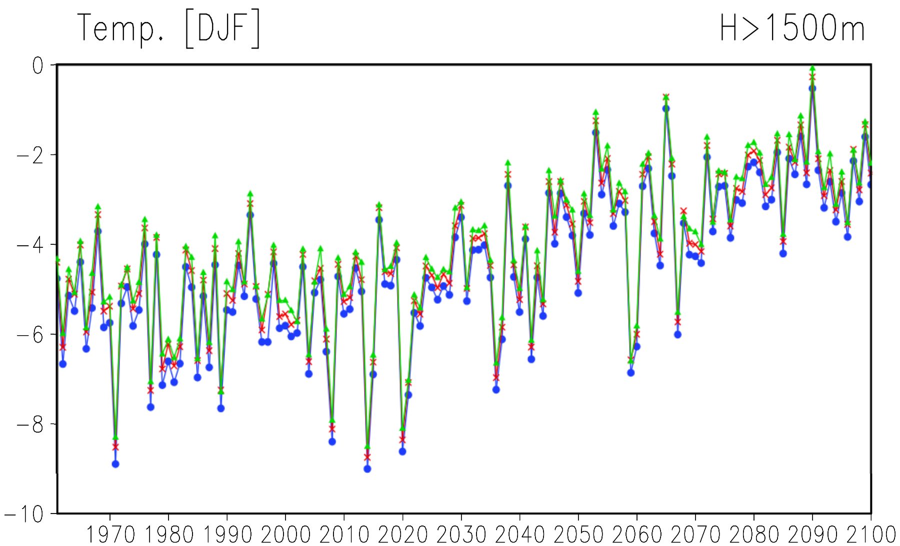
# ANN Temperature

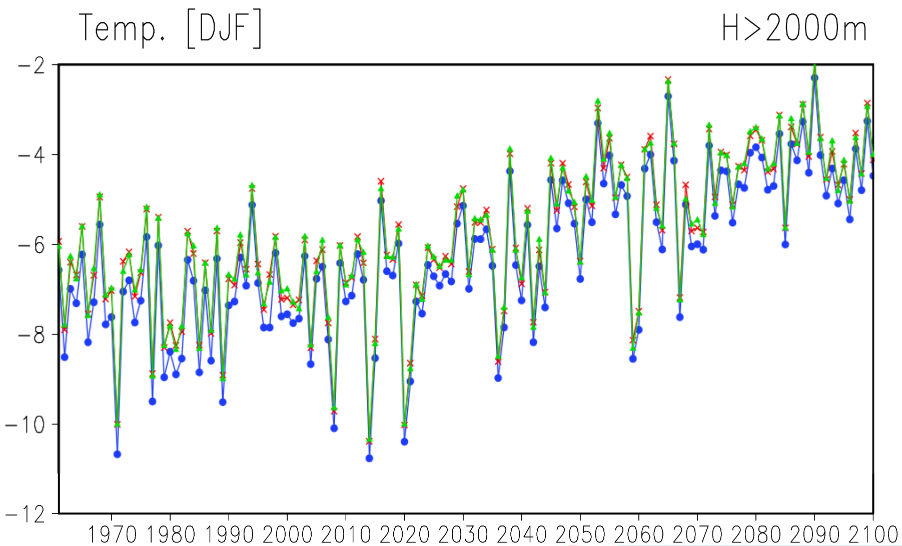


# DJF Temperature

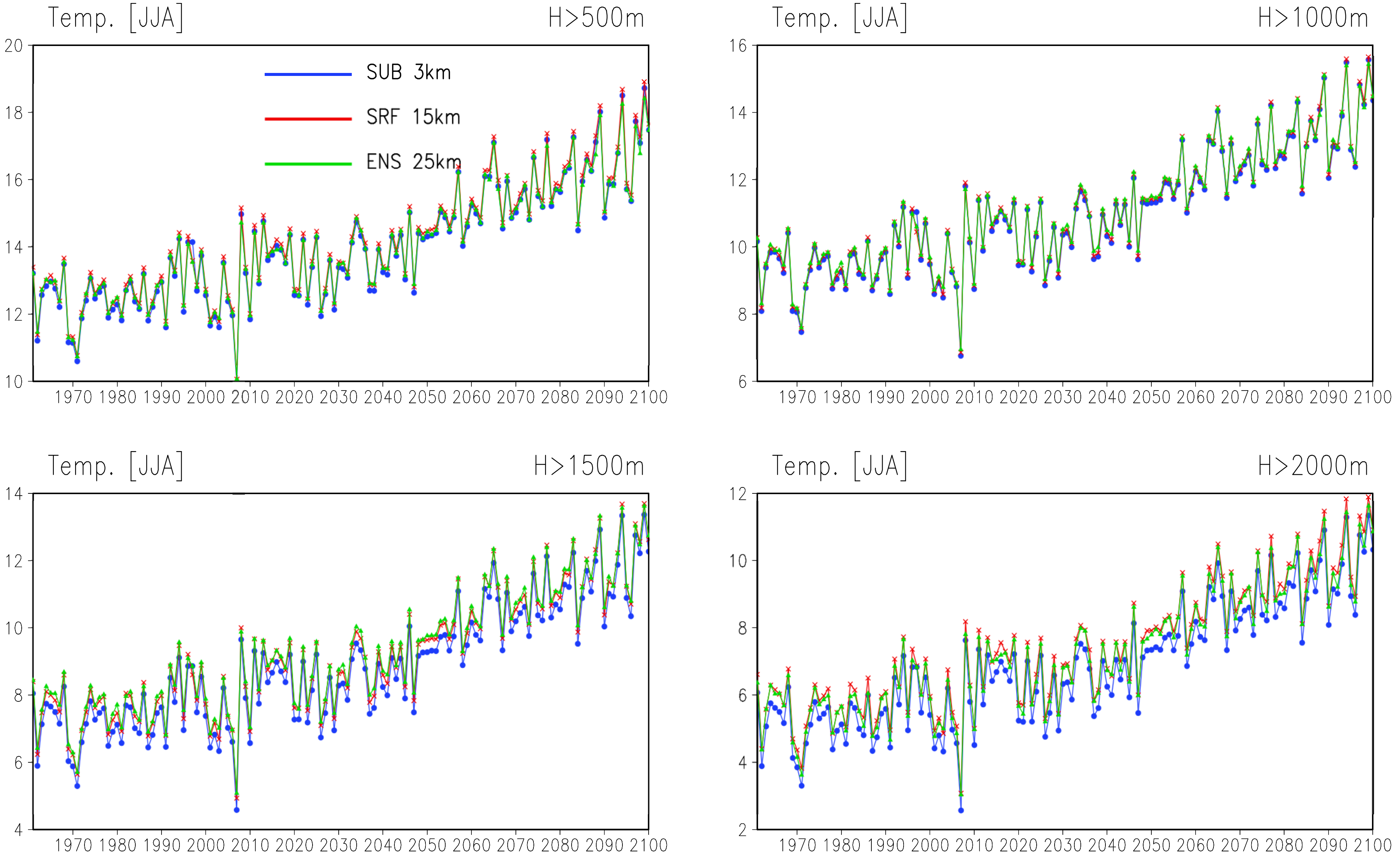


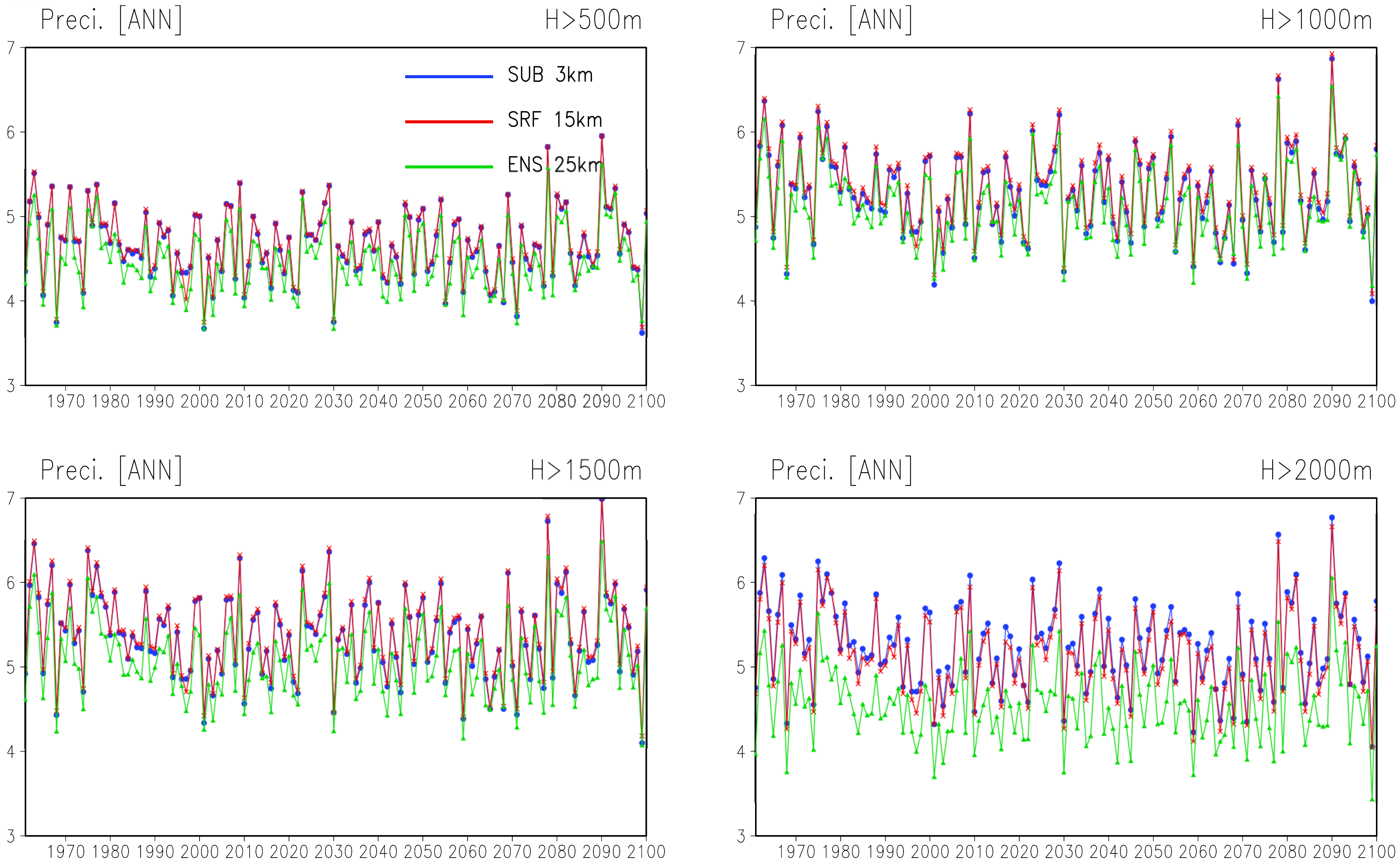



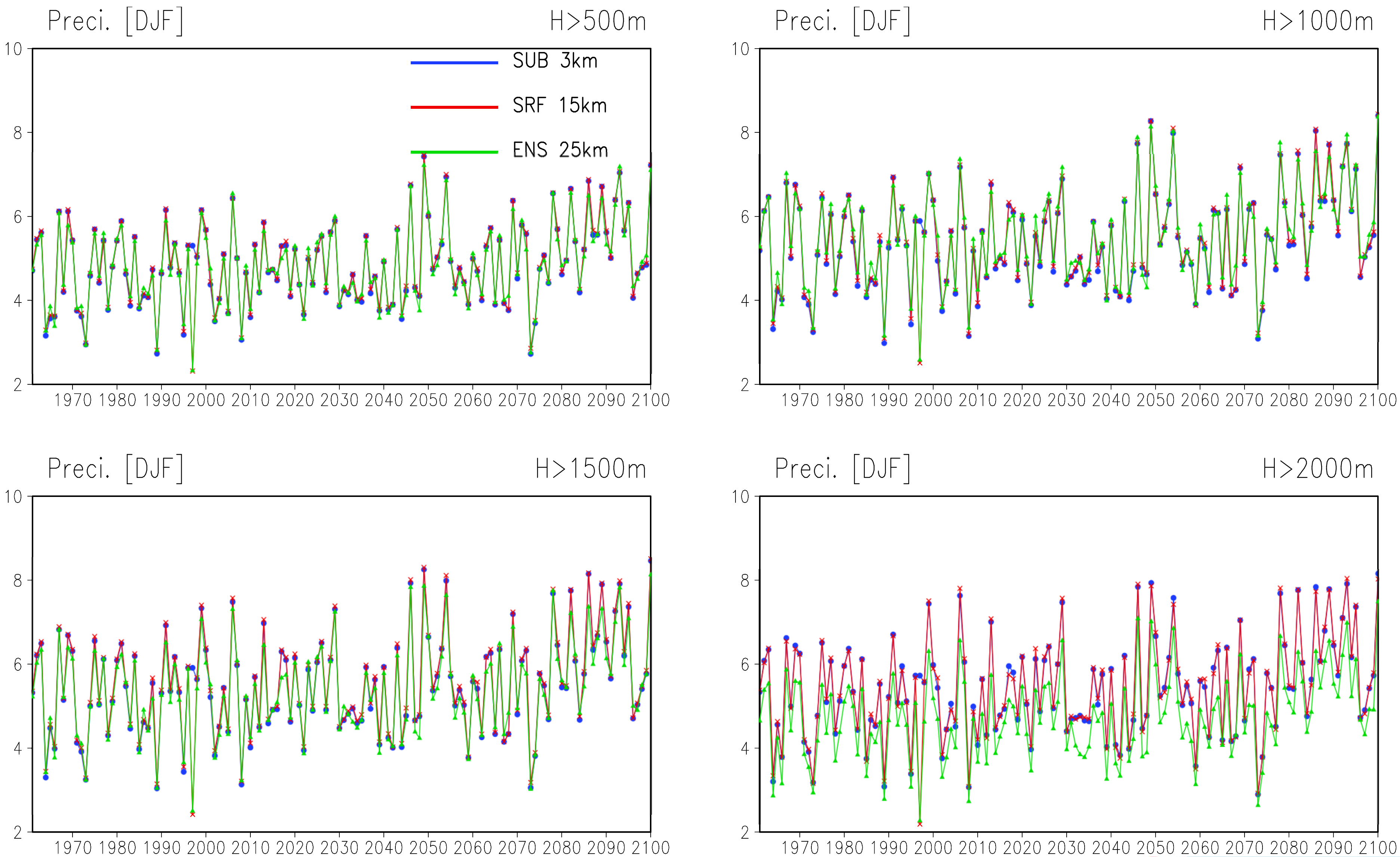
# JJA Temperature



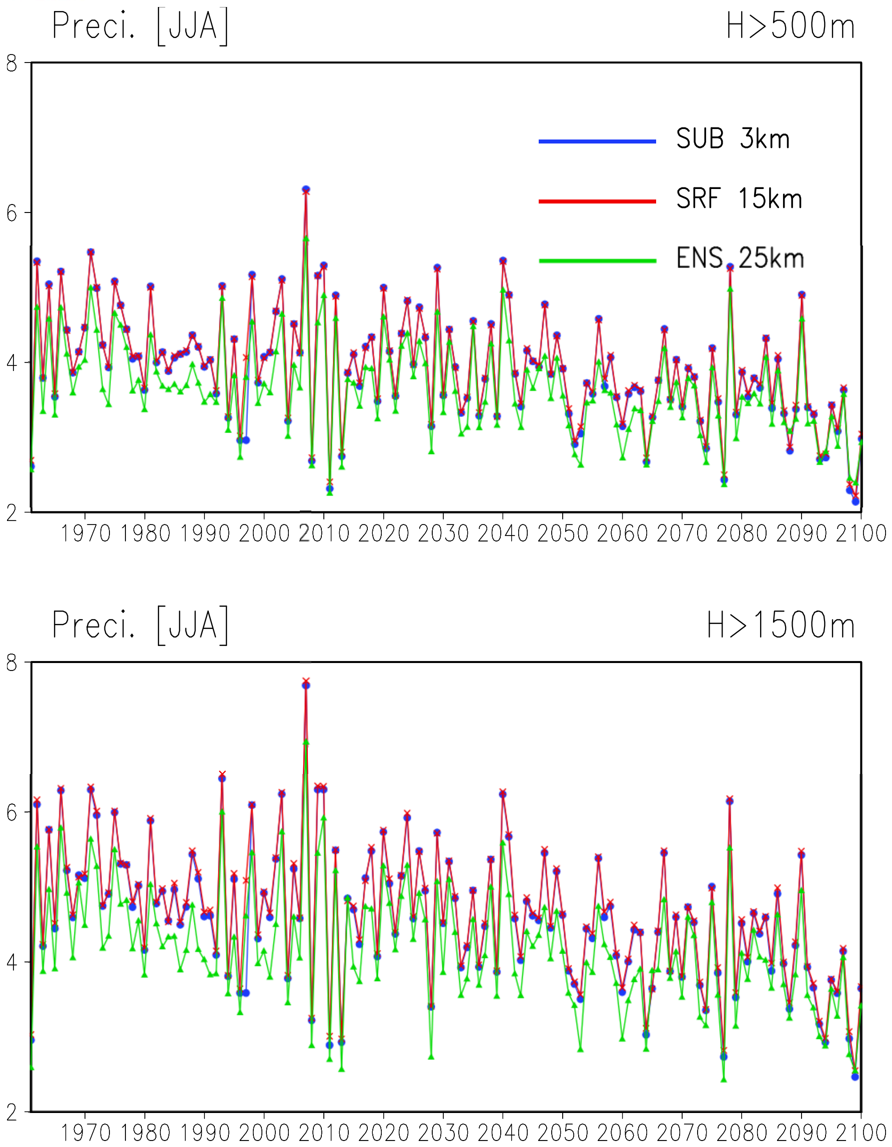
# ANN Precipitaiton



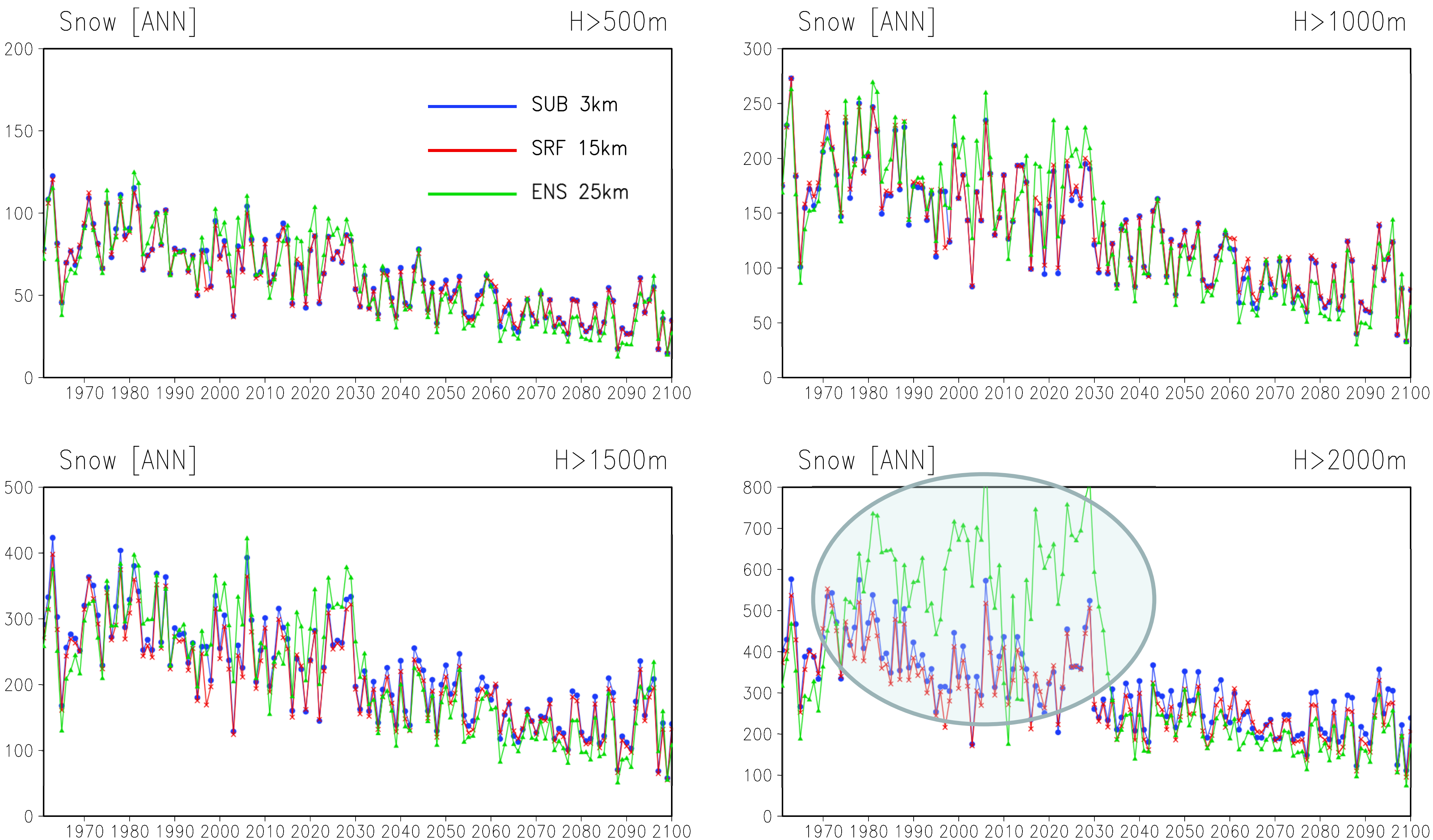
# DJF Precipitation



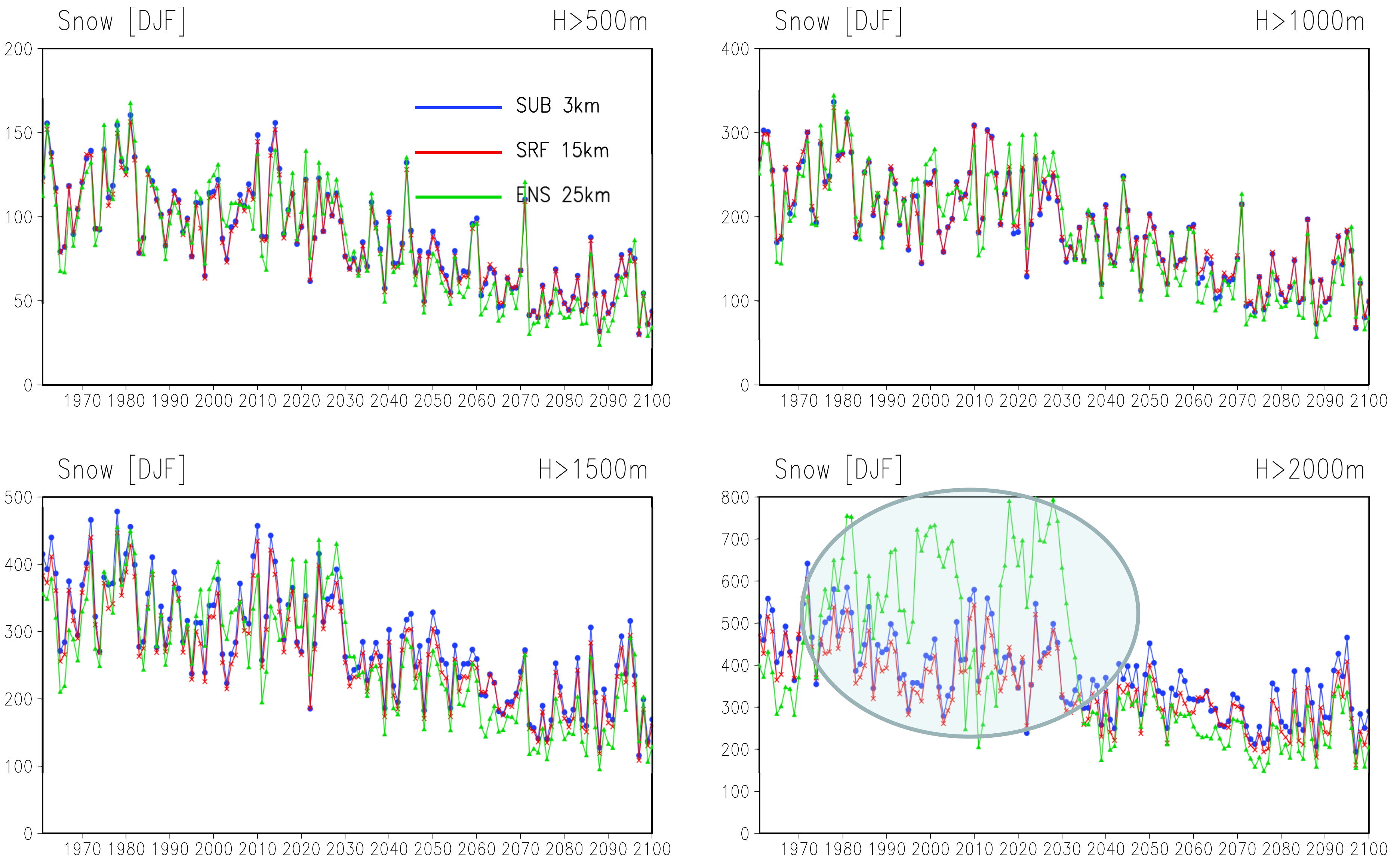
# JJA Precipitation



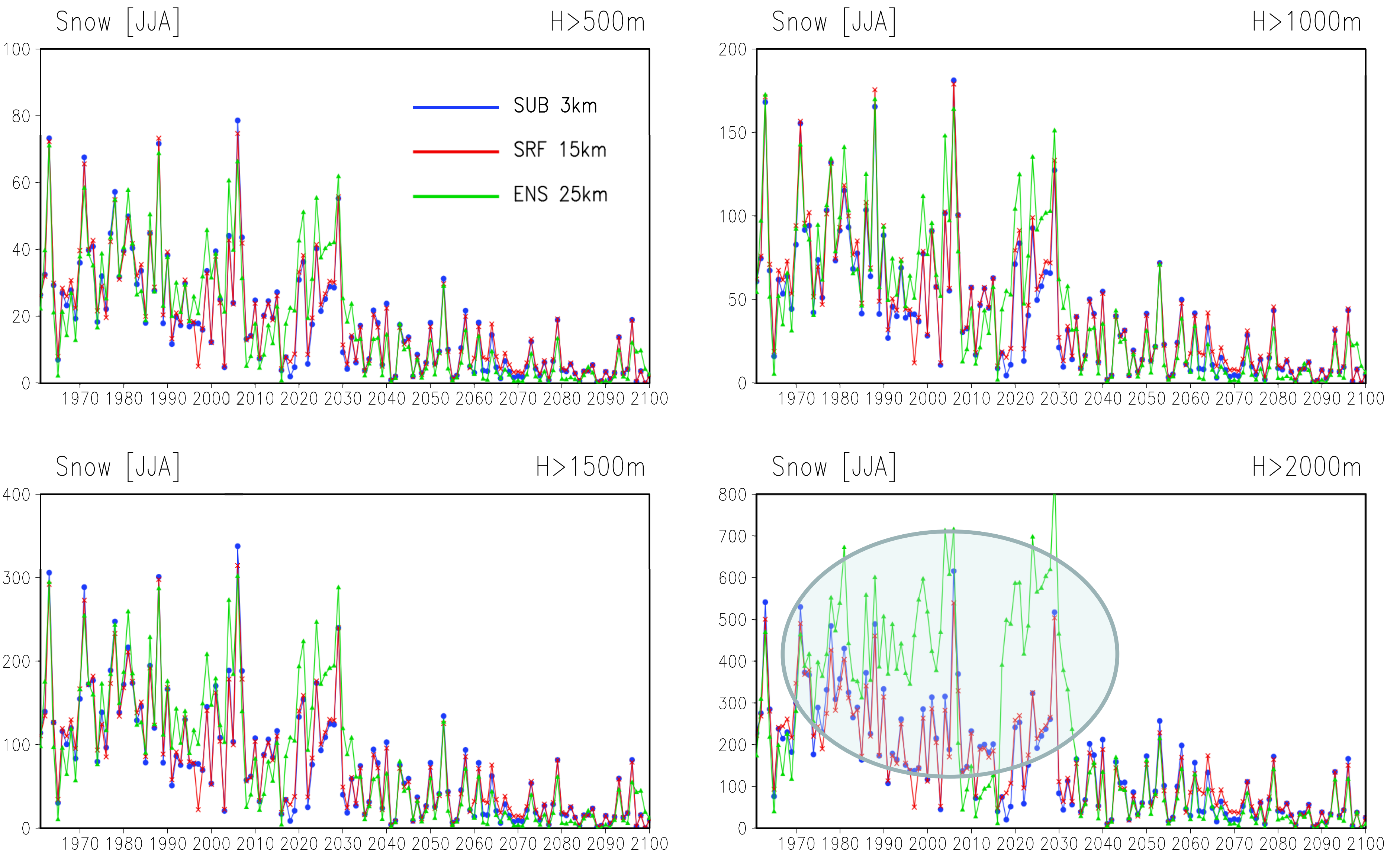
# Temporal evolution of ANN snow amount over Alps according to height



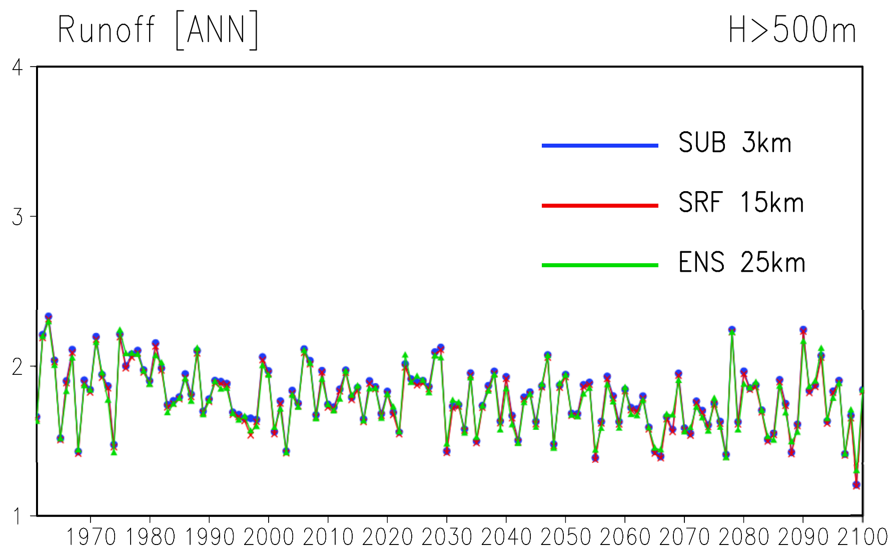
# DJF snow amount

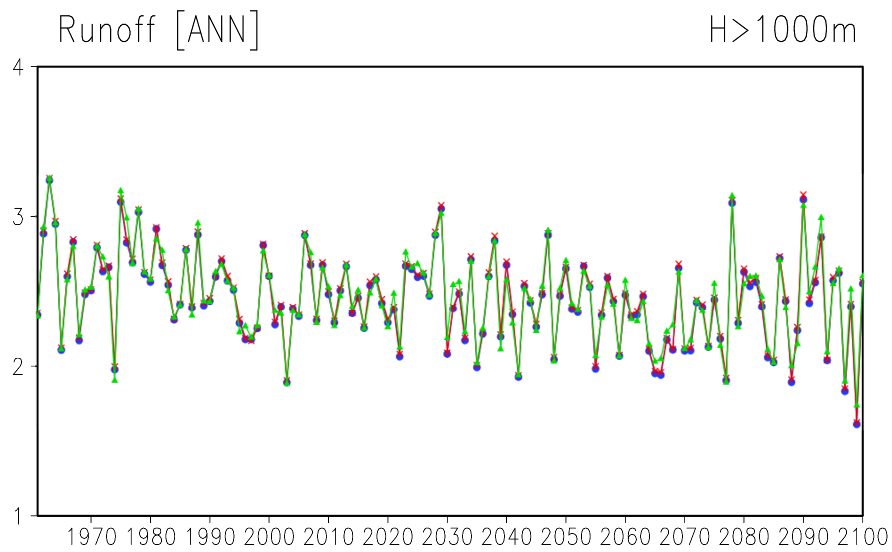


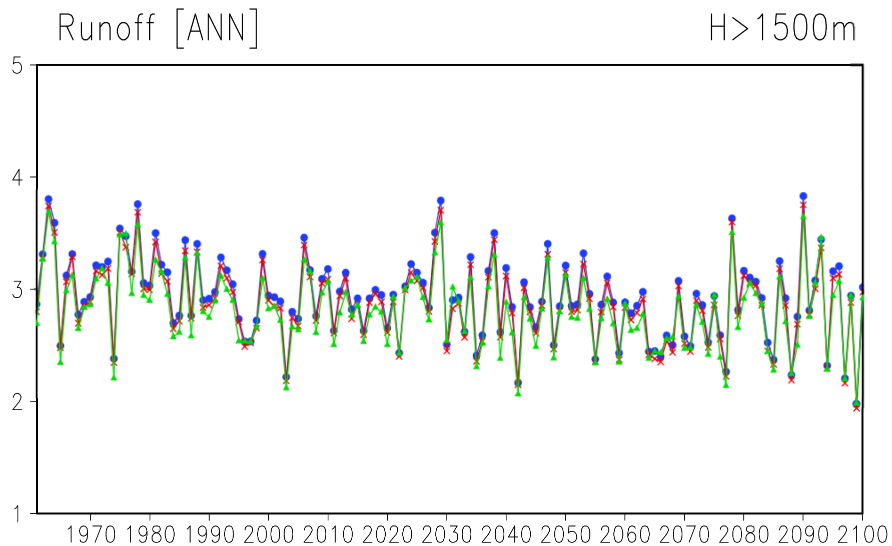
# JJA snow amount

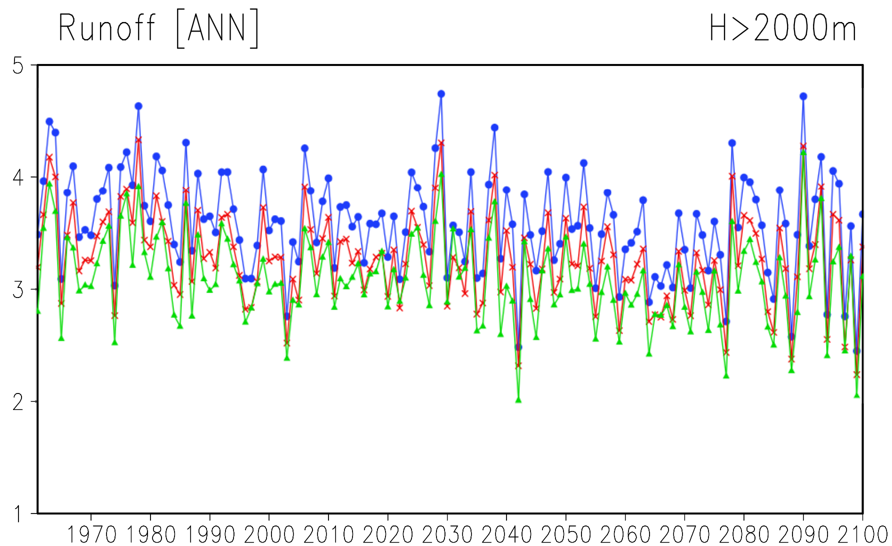


# ANN Runoff

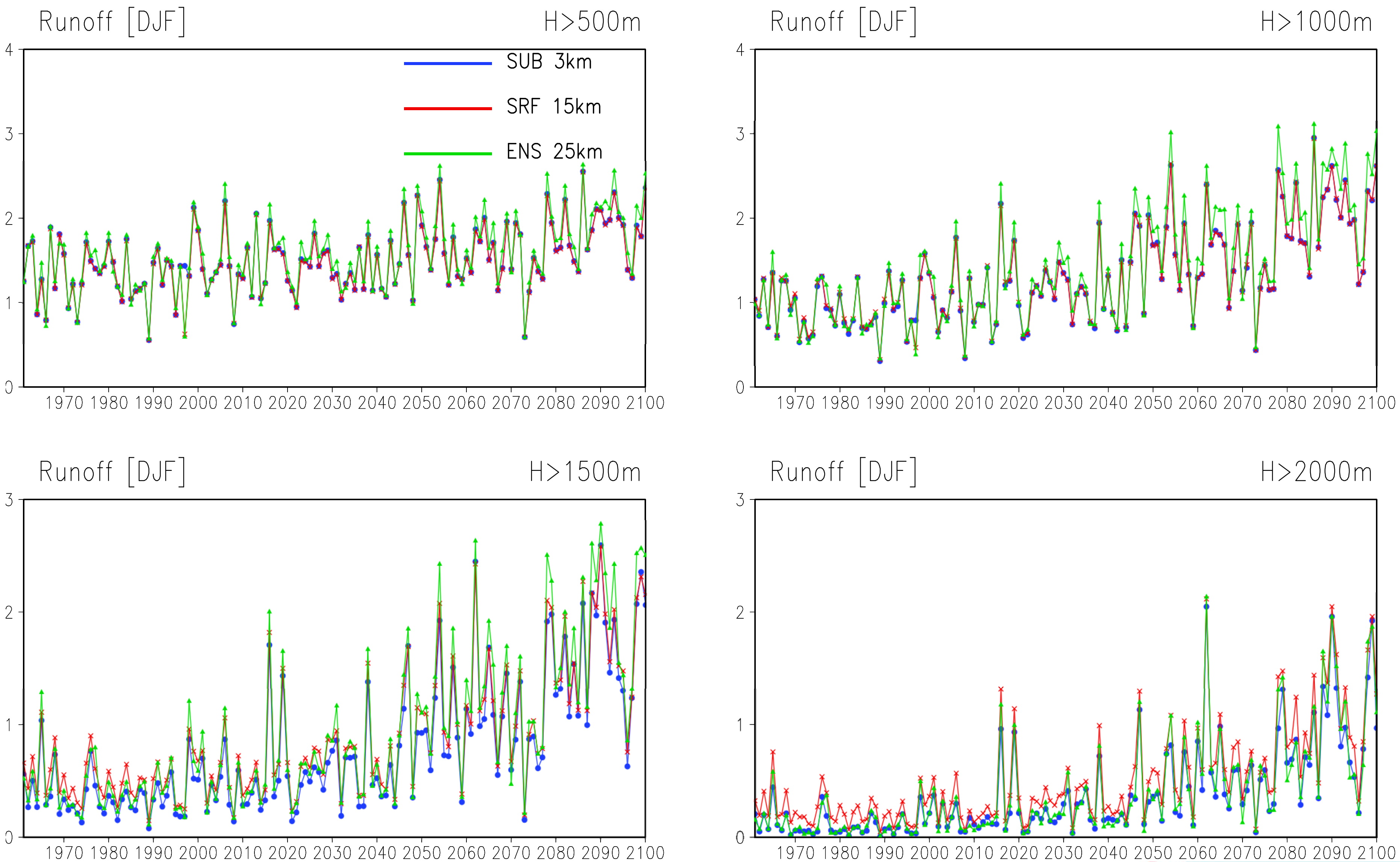

Runoff [ANN]
H>500m
SUB 3km
SRF 15km
ENS 25km
1970 1980 1990 2000 2010 2020 2030 2040 2050 2060 2070 2080 2090 2100


Runoff [ANN]
H>1000m
1970 1980 1990 2000 2010 2020 2030 2040 2050 2060 2070 2080 2090 2100

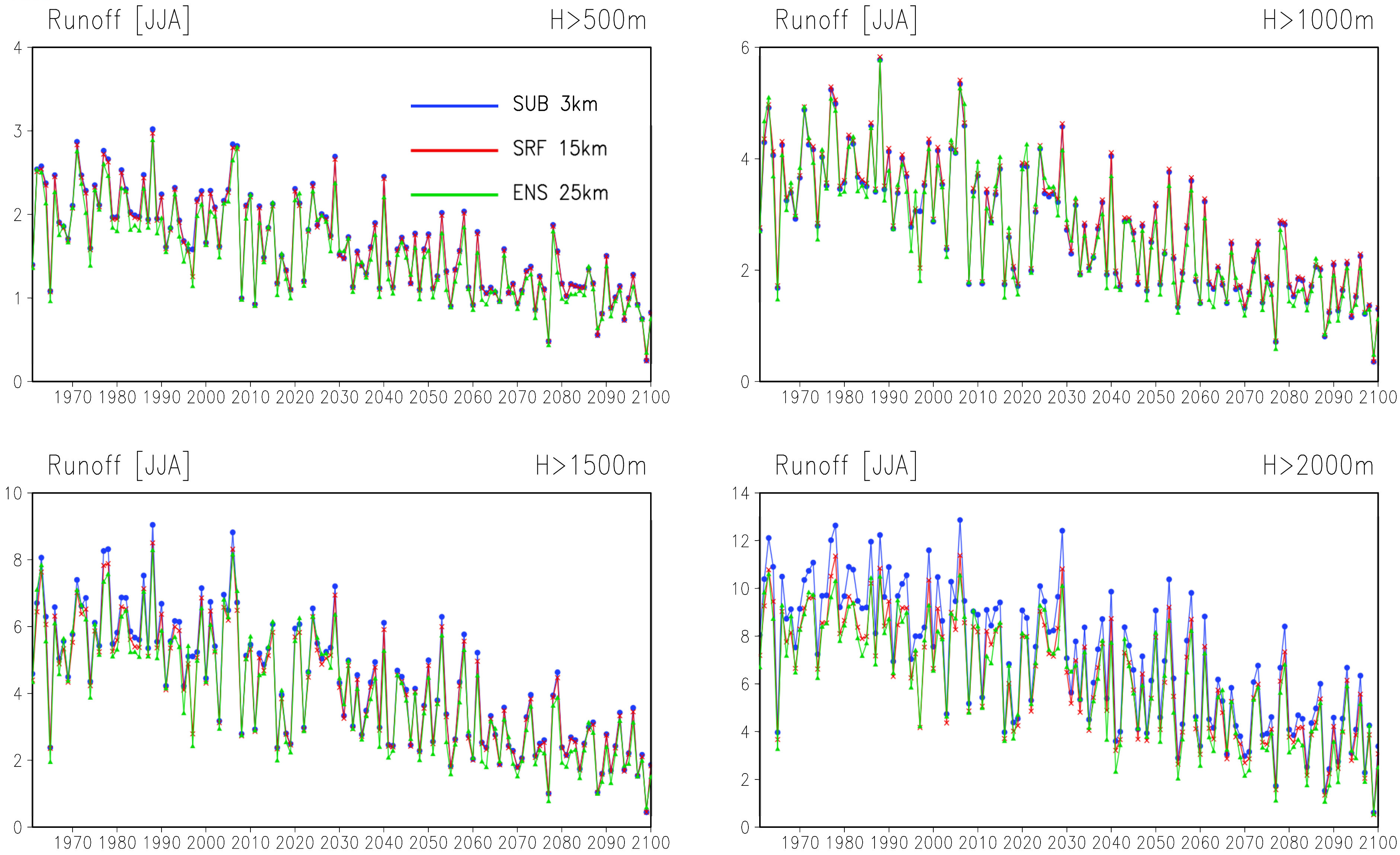

Runoff [ANN]
H>1500m
1970 1980 1990 2000 2010 2020 2030 2040 2050 2060 2070 2080 2090 2100


Runoff [ANN]
H>2000m
1970 1980 1990 2000 2010 2020 2030 2040 2050 2060 2070 2080 2090 2100

# DJF Runoff


Runoff [DJF]
H>500m
SUB 3km
SRF 15km
ENS 25km
Runoff [DJF]
H>1000m
Runoff [DJF]
H>1500m
Runoff [DJF]
H>2000m
1970 1980 1990 2000 2010 2020 2030 2040 2050 2060 2070 2080 2090 2100

# JJA Runoff



Runoff [JJA]
H>500m
SUB 3km
SRF 15km
ENS 25km
Runoff [JJA]
H>1000m
Runoff [JJA]
H>1500m
Runoff [JJA]
H>2000m
1970 1980 1990 2000 2010 2020 2030 2040 2050 2060 2070 2080 2090 2100

# Summary

- The climate change signal  does sow a resolution dependency

- This is more evident when different elevation are considered because changes in precipitation, as well as other components of the surface energy and water budgets do show an elevation signal

- This substantial elevation dependency can be important for impact assessment studies  focusing on water availability and water quality, hydropower generation, freshwater  supply, irrigation.