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CLIMATE CHANGE RESEARCH

Future Changes in Moisture Transport towards the Alps

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Motivation – Moisture Transport

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Atmospheric Moisture Transport

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Moisture Transport

Integrated Vapor Transport IVT

- Magnitude
- Direction

Froidevaux and Martius (2016)

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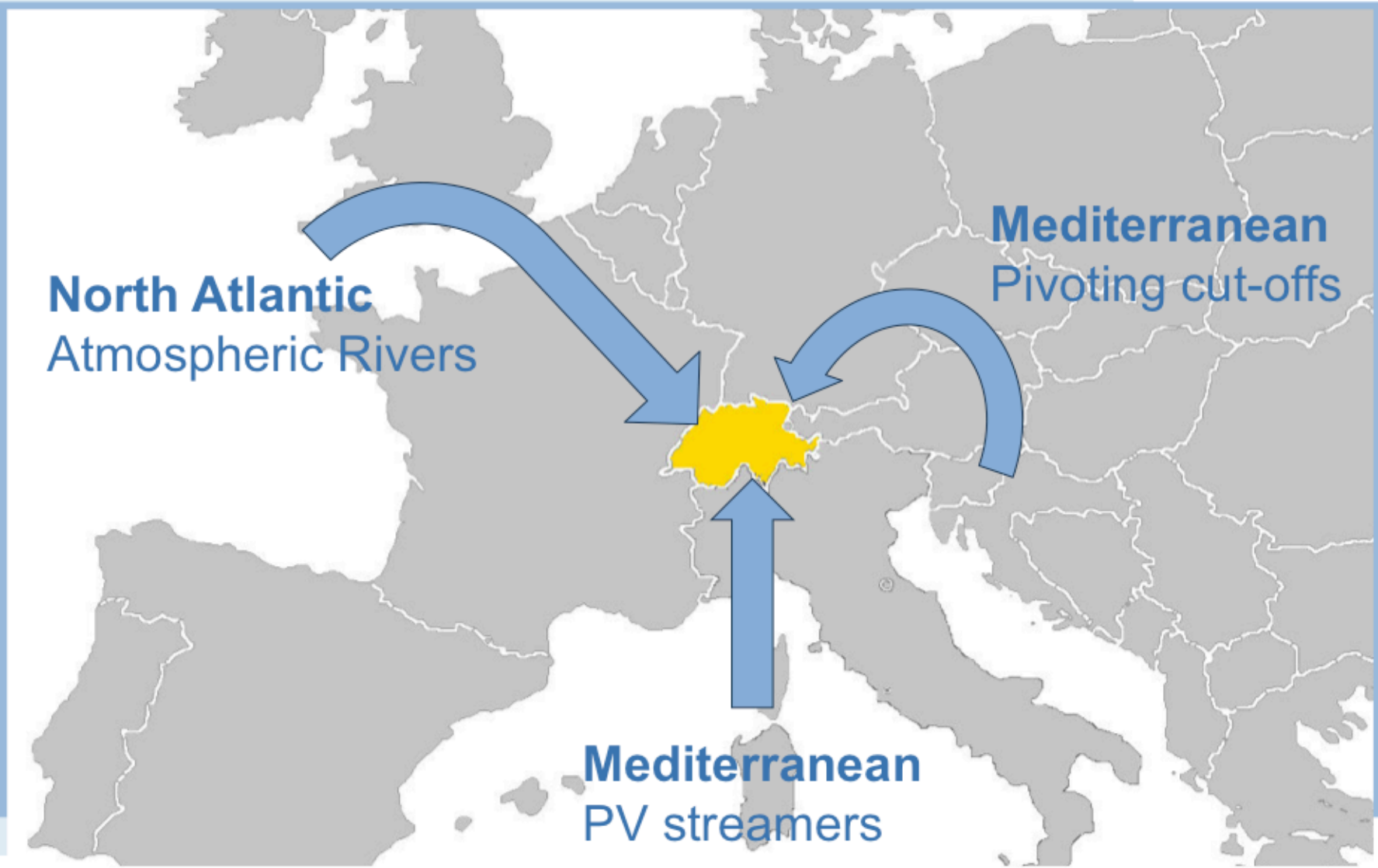

All IVT vs direction dependent IVT

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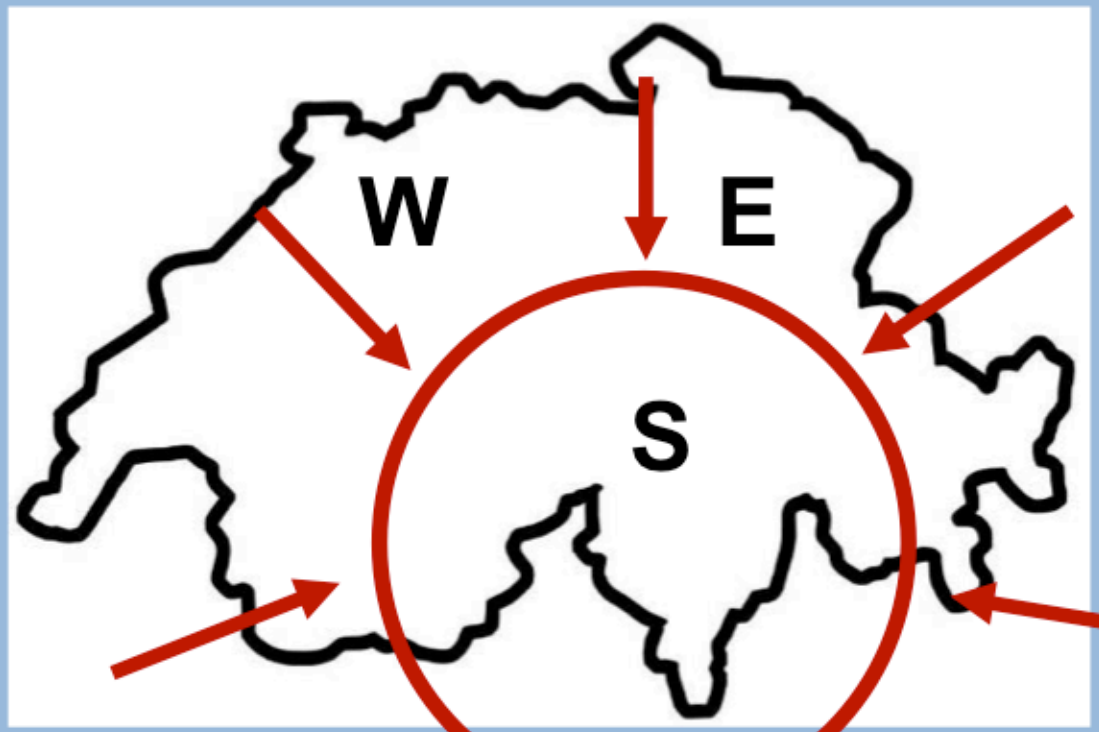

All
Direction dependent

All IVT vs direction dependent IVT

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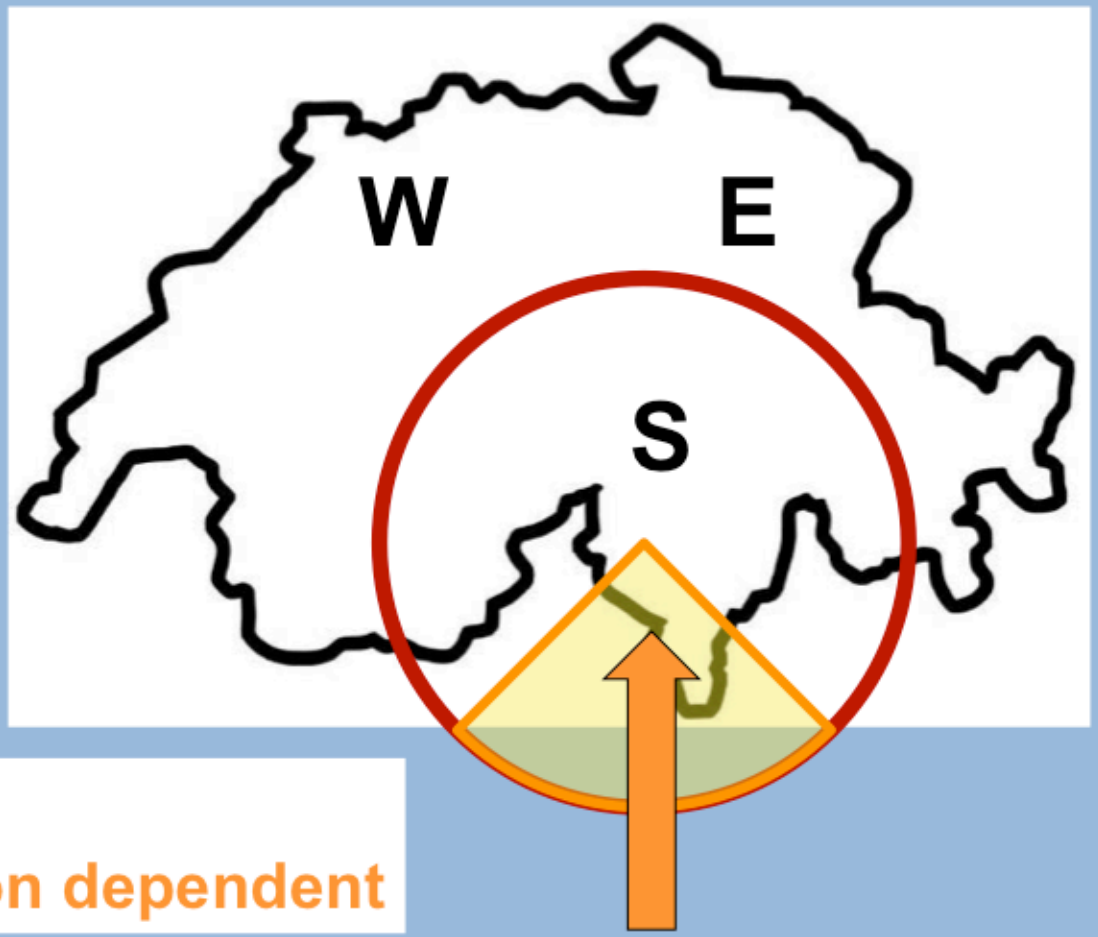

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All IVT vs direction dependent IVT

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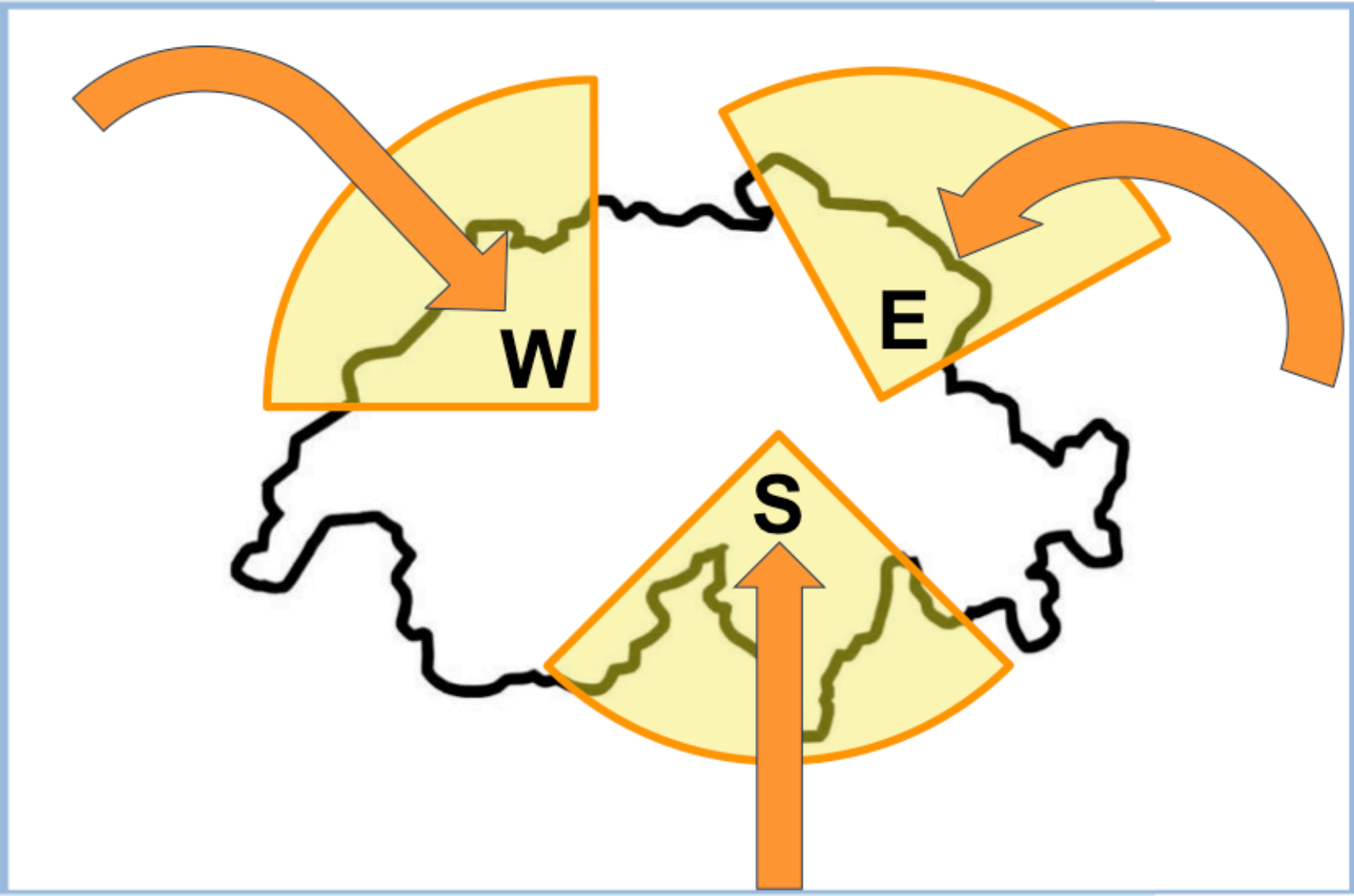

Data & Methods

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- CMIP5 models with RCP8.5
  - Selected based on horizontal, vertical and temporal resolution
  - CNRM-CM5: 1.5x1.5° resolution
    GFDL-ESM2G: 2x2° resolution;
    GFDL-CM3: 2x2° resolution;

- Moderate Extremes
  - 99th percentile of IVT
  - All IVT and direction dependent IVT

- Very Extreme IVT
  - Fit GEVs to all and direction dependent IVT maxima
  - comparison of fitted parameters

Change of IVT - 99th percentile

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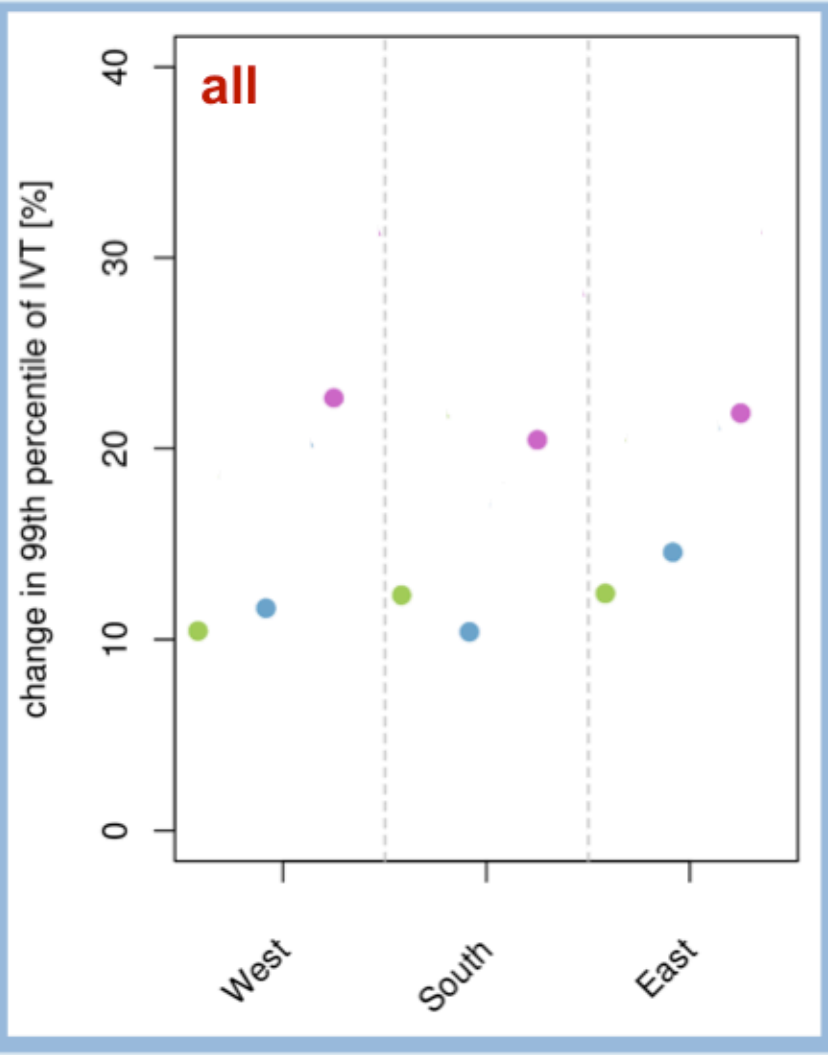
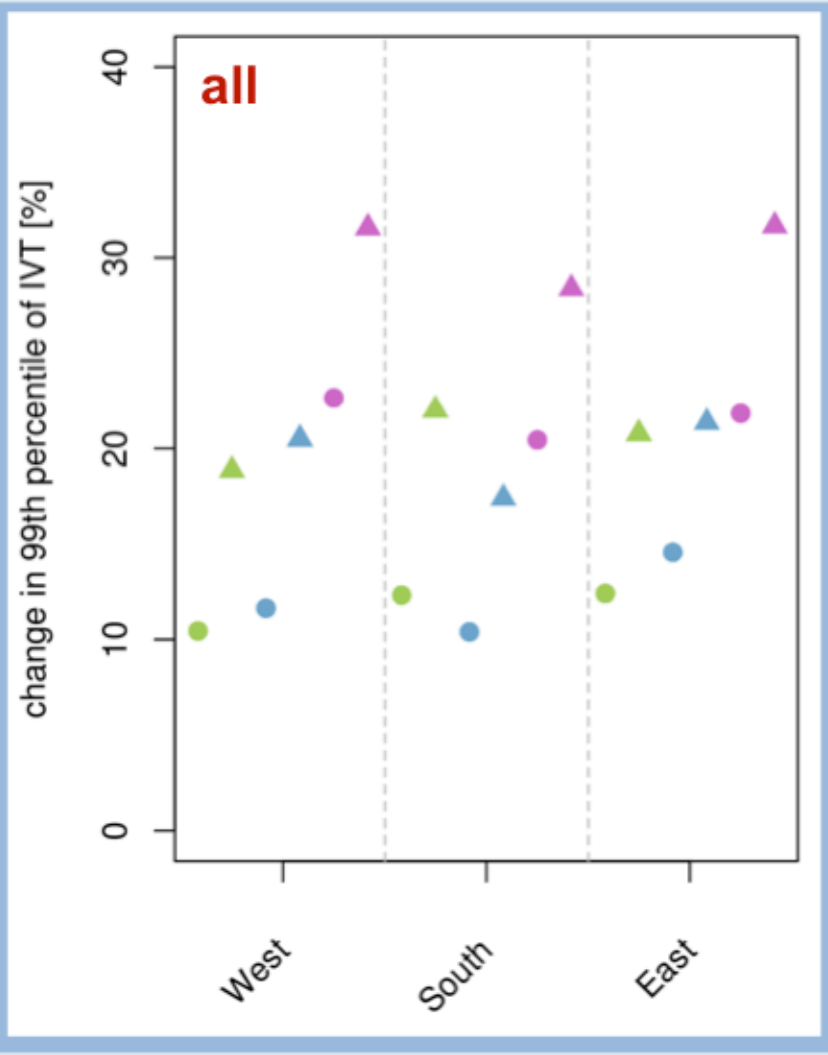


GFDL-ESM2G
CNRM-CM5
GFDL-CM3

2040-2069
2070-2099

Reference:
1979-2005

Change of IVT - 99th percentile



GFDL-ESM2G
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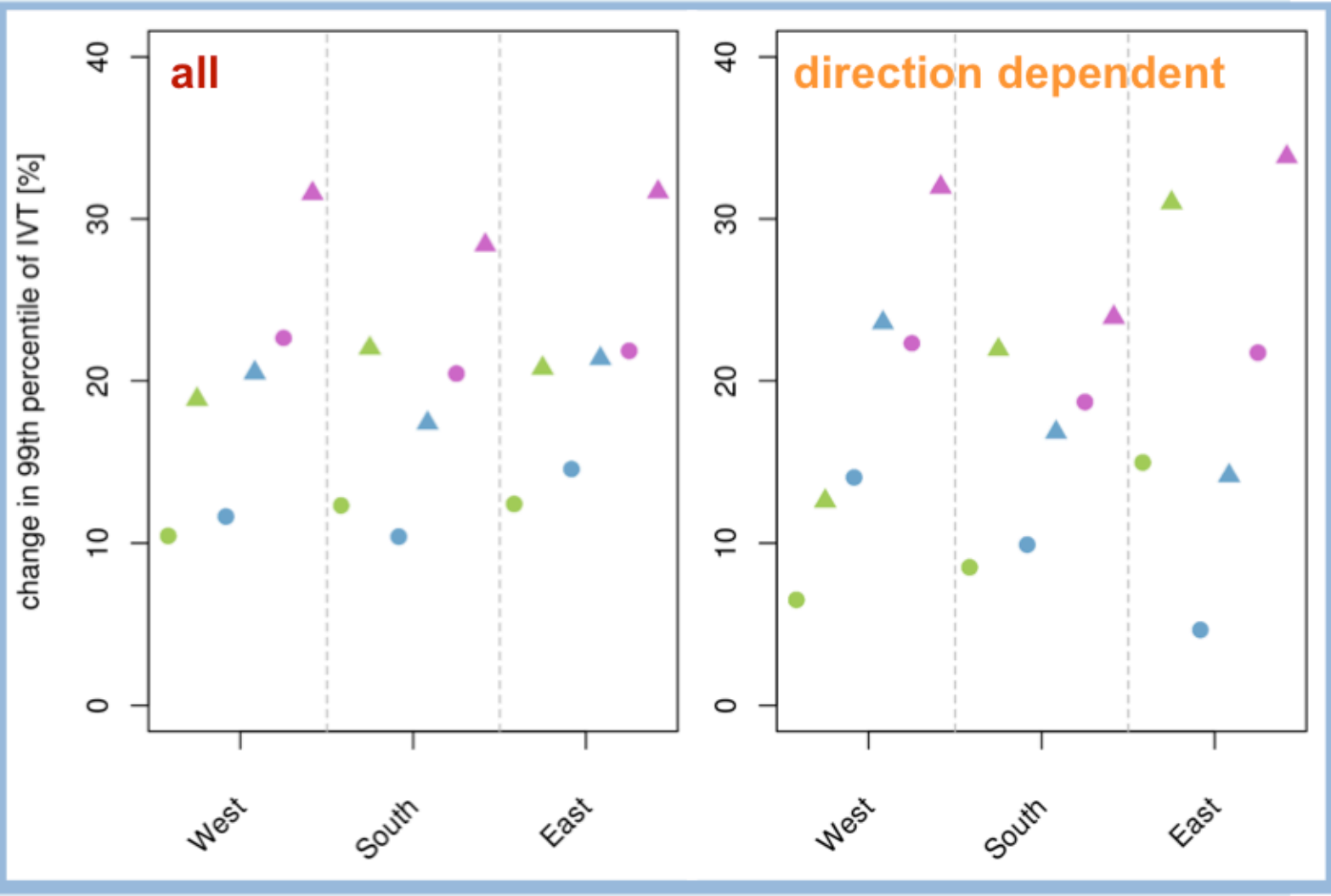

Reference: 1979-2005

Extreme IVT – GEV

$$G(x) = \exp\left\{-\left[1 + \frac{\xi(x-\mu)}{\sigma}\right]^{\frac{-1}{\xi}}\right\}$$

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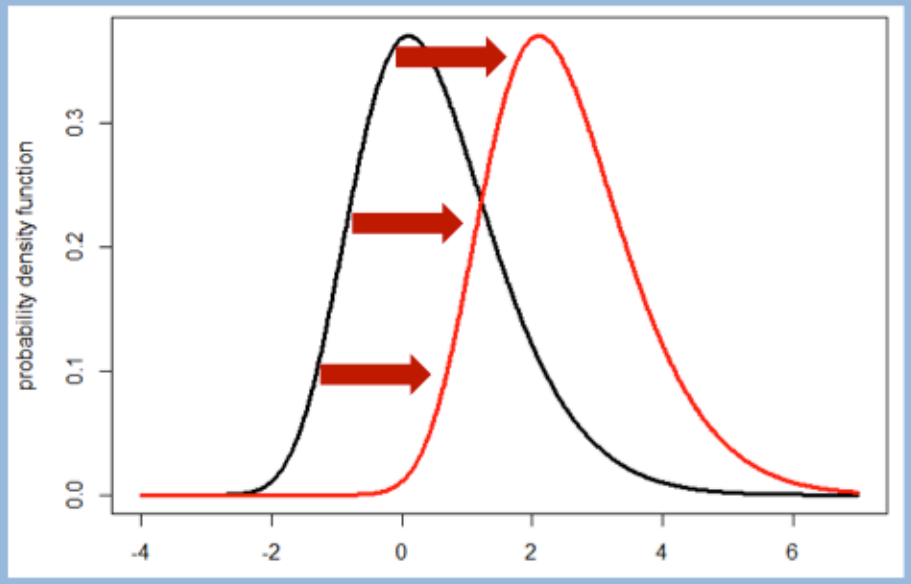
- Procedure:
  - Select yearly block maxima for 2006-2100
  - Fit GEV parameters: location **μ** , scale **σ** , shape **ξ**
  - Model non-stationarity in location parameter

$$Z_t \sim GEV(\mu(t), \sigma, \xi)$$

$$\mu(t) = \beta_0 + \beta_1 t$$

$$t: 2006 - 2100$$



Trend in location parameter

$$\mu(t) = \beta_0 + \boldsymbol{\beta_1} t$$

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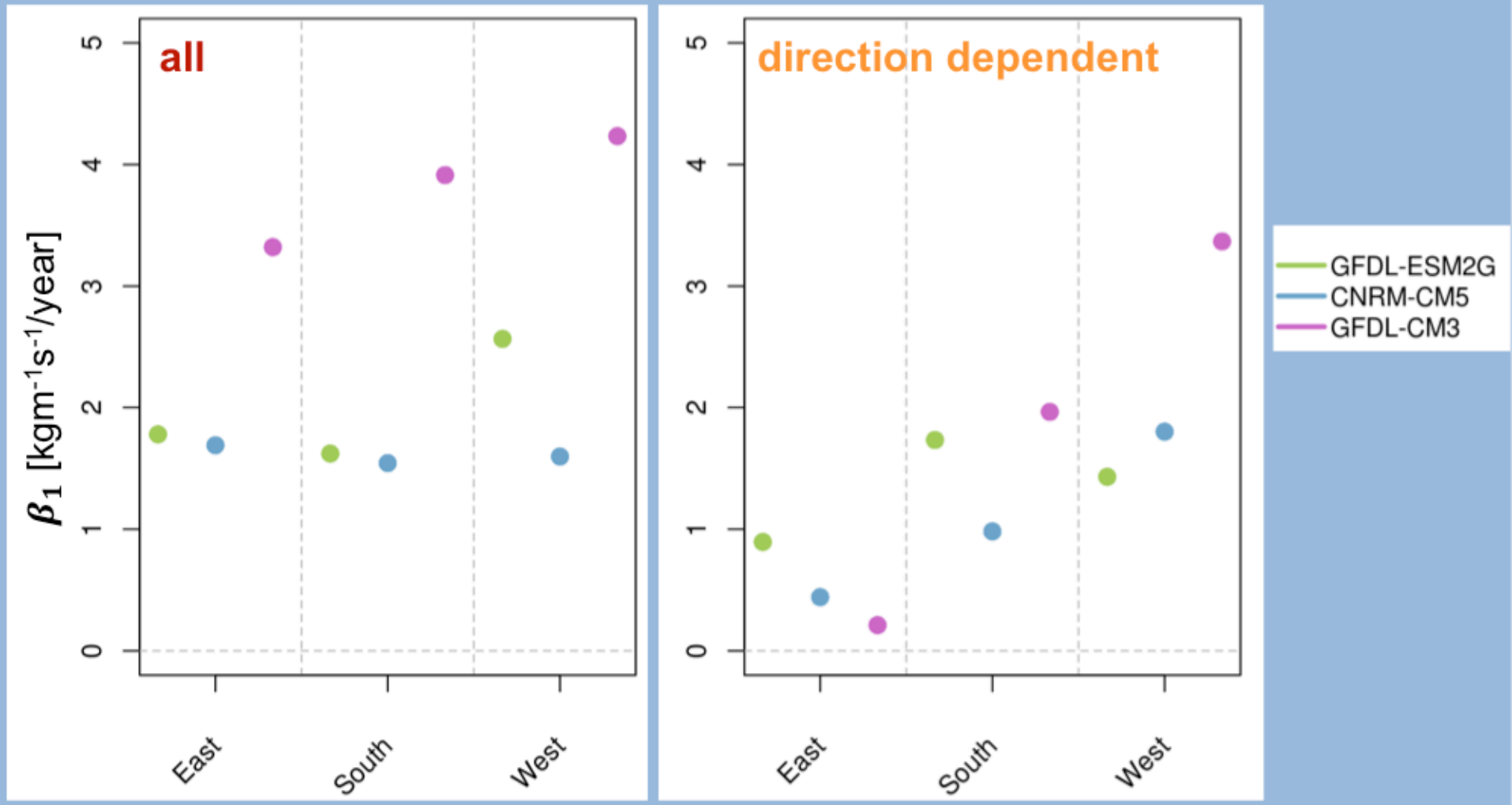

Shift in location parameter by 2100

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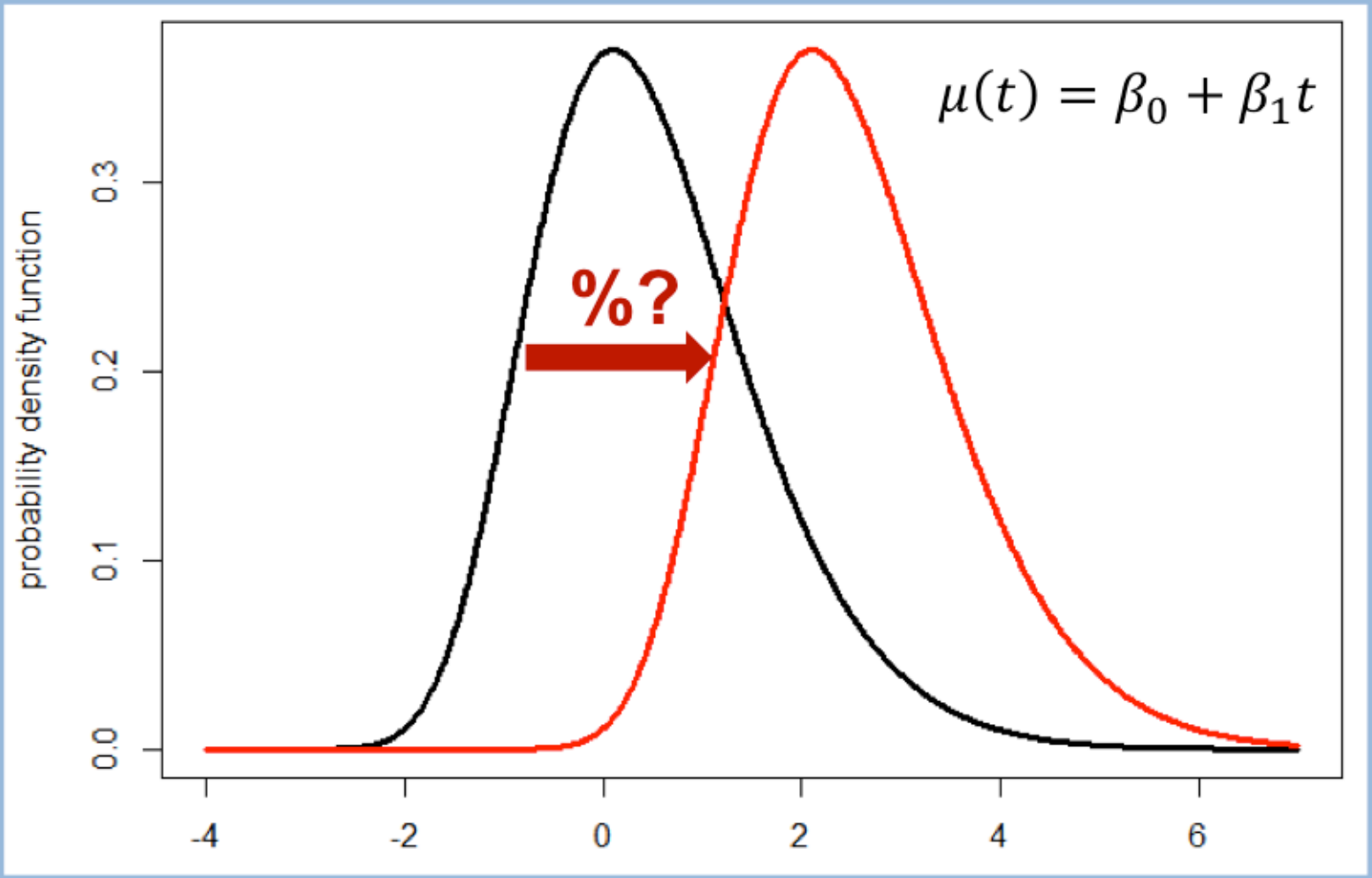

Shift in location parameter by 2100

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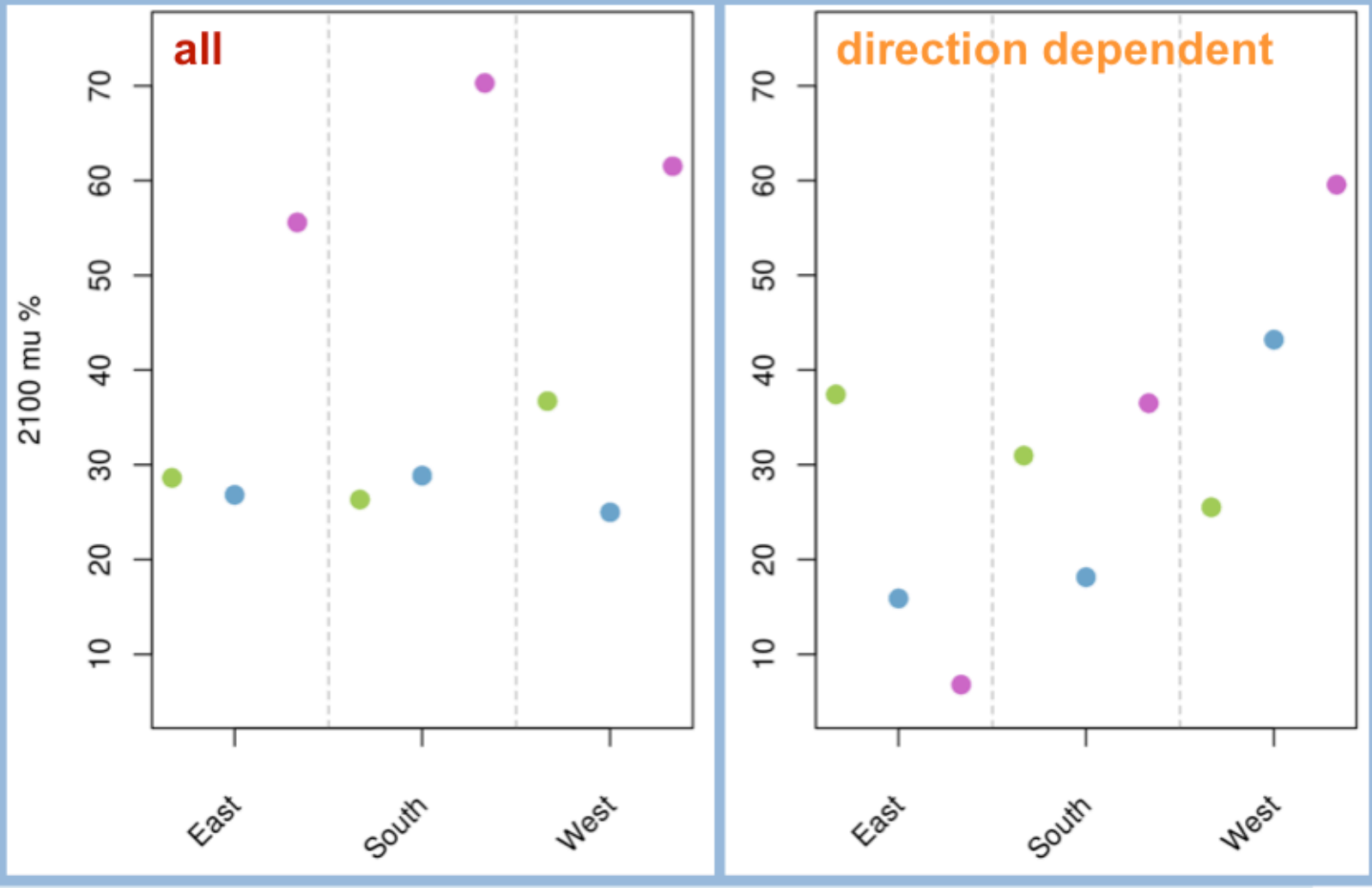

Simple thermodynamic explanation?

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- Clausius-Clapeyron: ~7% /K

	ΔT*	CC	shift all
GFDL-ESM2G:	~ 4K	28%	30-40%
CNRM-CM5:	~ 4.5K	31%	30-40%
GFDL-CM3:	~ 6-8K	42-56%	55-70%

*European temperature change after Cattiaux et al. 2013

Simple thermodynamic explanation?

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- Clausius-Clapeyron: ~7% /K

	ΔT*	CC	shift all	shift dirdep
GFDL-ESM2G:	~ 4K	28%	30-40%	25-40%
CNRM-CM5:	~ 4.5K	31%	30-40%	15-45%
GFDL-CM3:	~ 6-8K	42-56%	55-70%	5-60%

*European temperature change after Cattiaux et al. 2013

Conclusions

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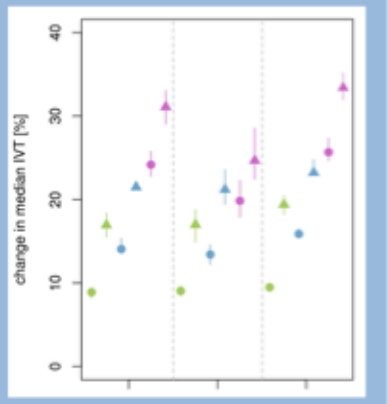
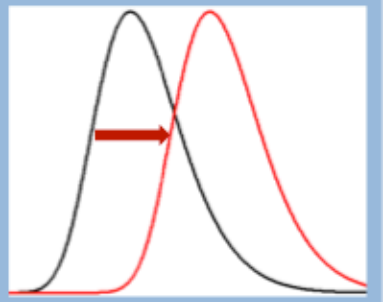
- **Intensification of moisture transport towards Switzerland**
  - differences larger the more distant in future
  - absolute differences larger the more extreme the IVT



- **Extremes more intense with climate change**
  - Positive trend in location parameter
  - Shift in extremes depends highly on model
    - all IVT values: 20-70%
    - direction dependent IVT values: 5-60%
  - Change not purely thermodynamically driven



Outlook

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- Include other models (CMIP5, different resolution)
- Differences between models
- Thermodynamic and dynamic contribution to the changes

Integrated Vapor Transport (IVT)

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$$\mathrm{IVT} = \frac{1}{g}\sqrt{\left(\int_{p=1000}^{p=0} qu\,\mathrm{d}p\right)^2 + \left(\int_{p=1000}^{p=0} qv\,\mathrm{d}p\right)^2}$$

$$\left[\mathrm{kg\,m^{-1}s^{-1}}\right]$$

q = specific humidity
u = zonal wind component
v = meridional wind component
p = pressure
g = acceleration due to gravity

Region of Interest

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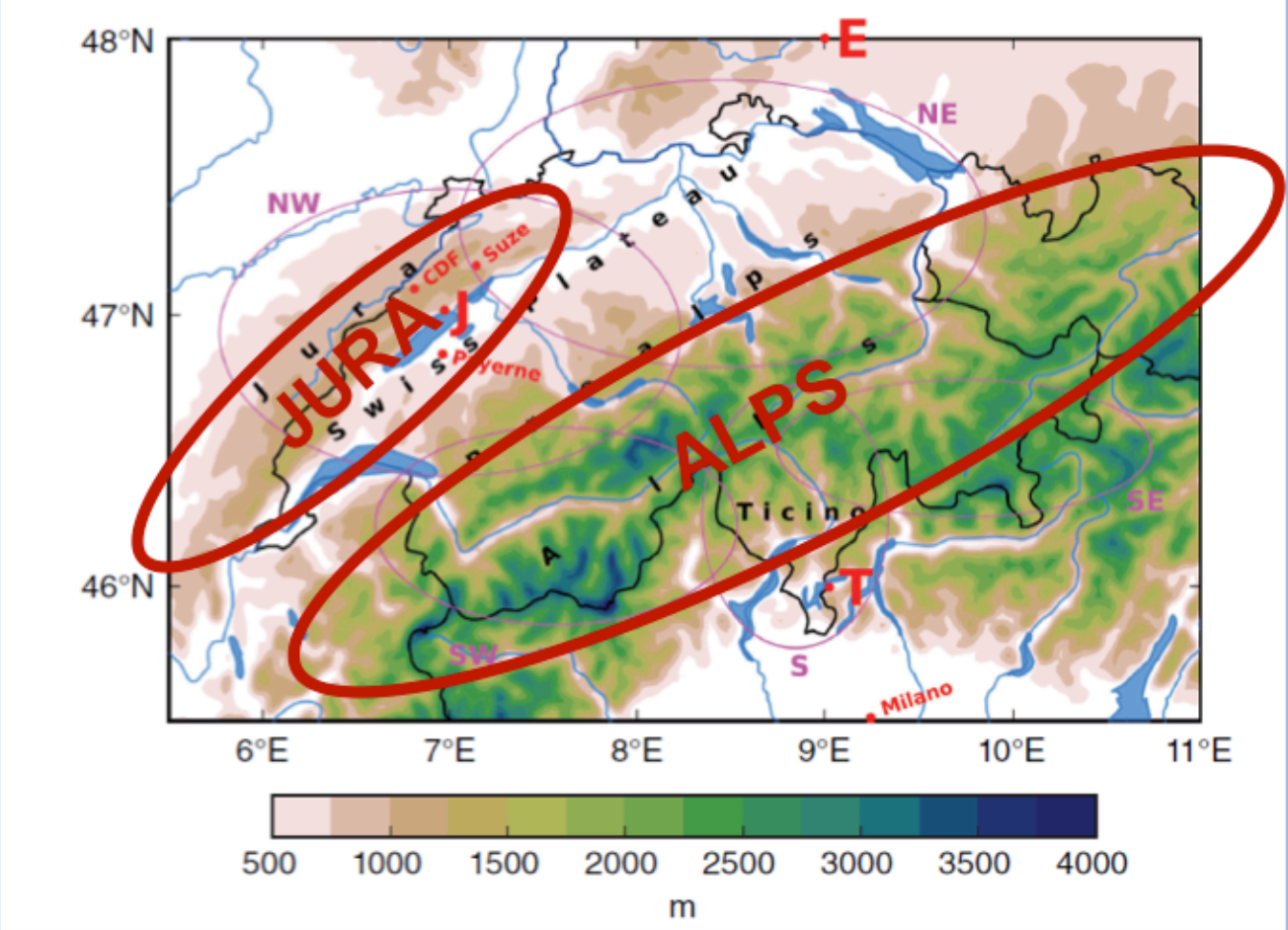
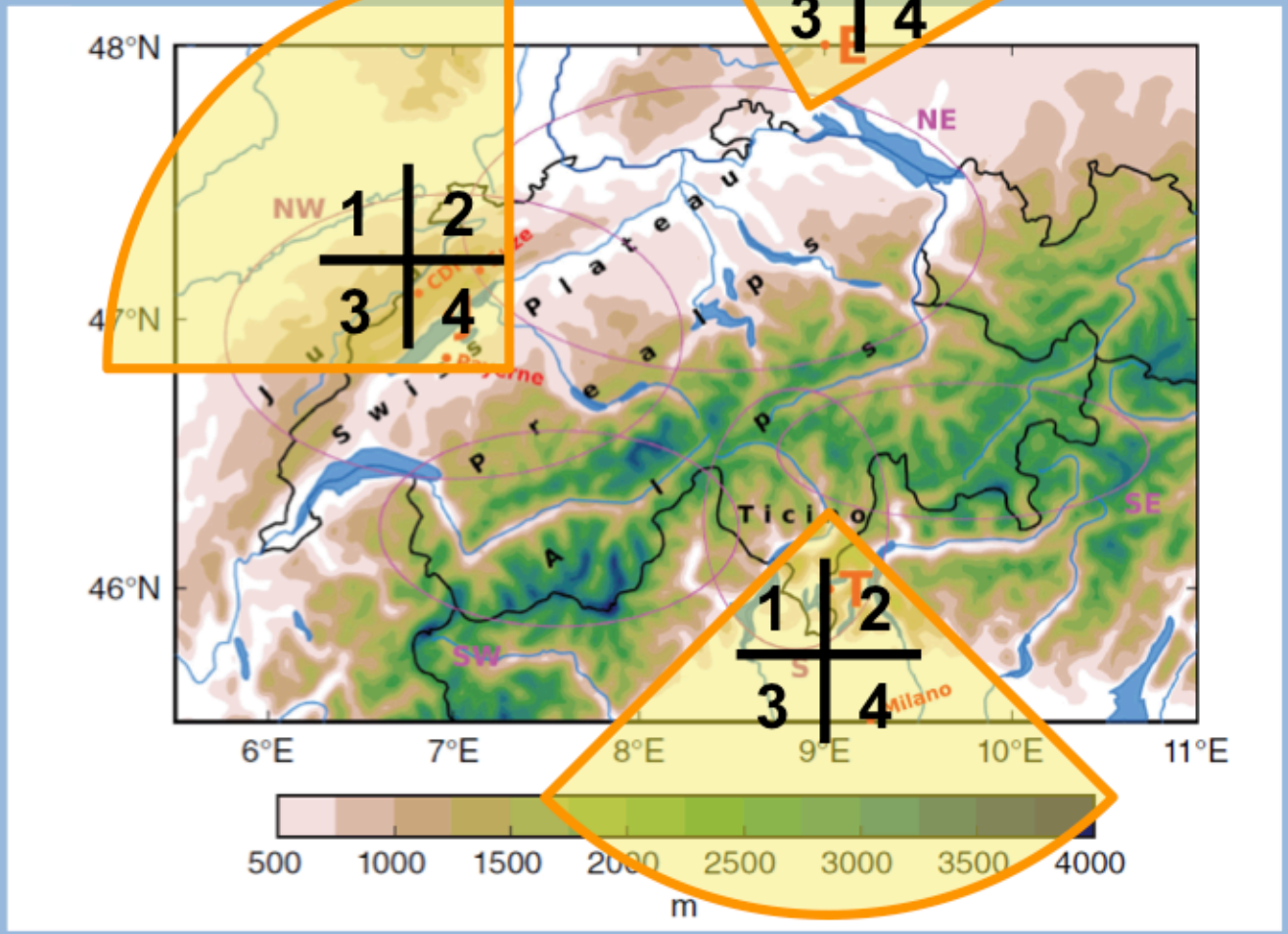


(adapted from Froidevaux and Martius, 2016)

Point selection



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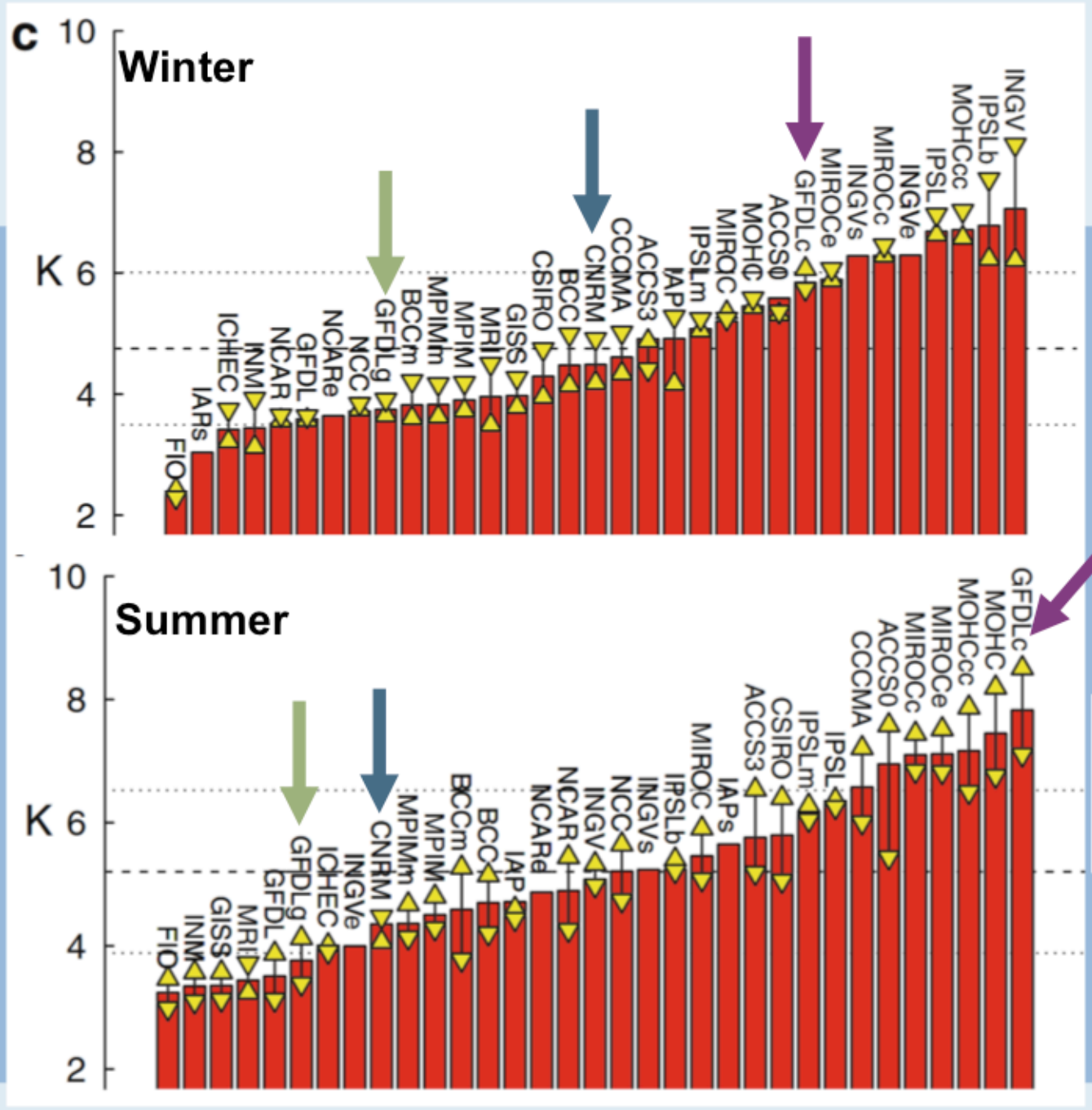

Cattiaux et al. 2013