# Climate and tourism in Alpine destinations

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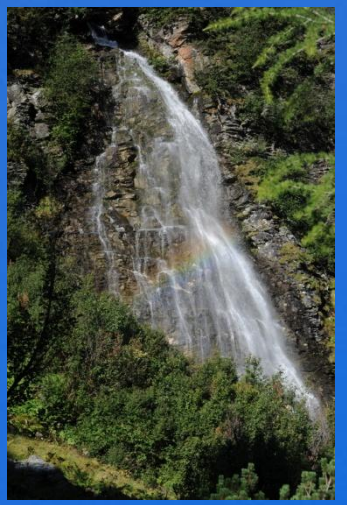


# Tourism Climate Index (TCI)



$$TCI=8*Cld+2*Cla+4*R+4*S+2*W$$

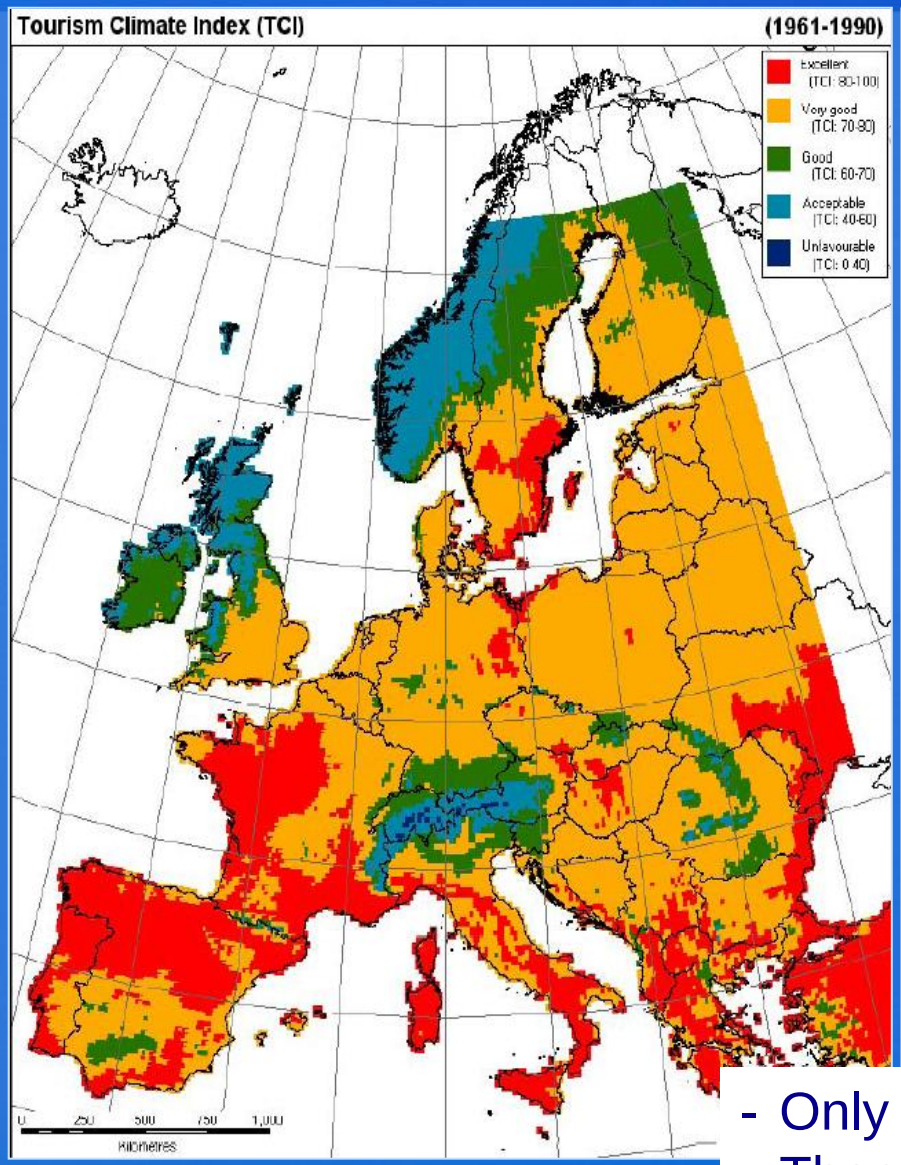
- Cld Day comfort index, $T_{a,max}$ (°C) mean daily maximum air temperature and l lowest mean relative humidity RH (%),
- Cla Day comfort index, consisting of mean $T_a$ (°C) and mean relative humidty (%),
- R Precipitation (mm),
- S Sunshine-hours per day (h),
- W Mean wind velocity (m/s).

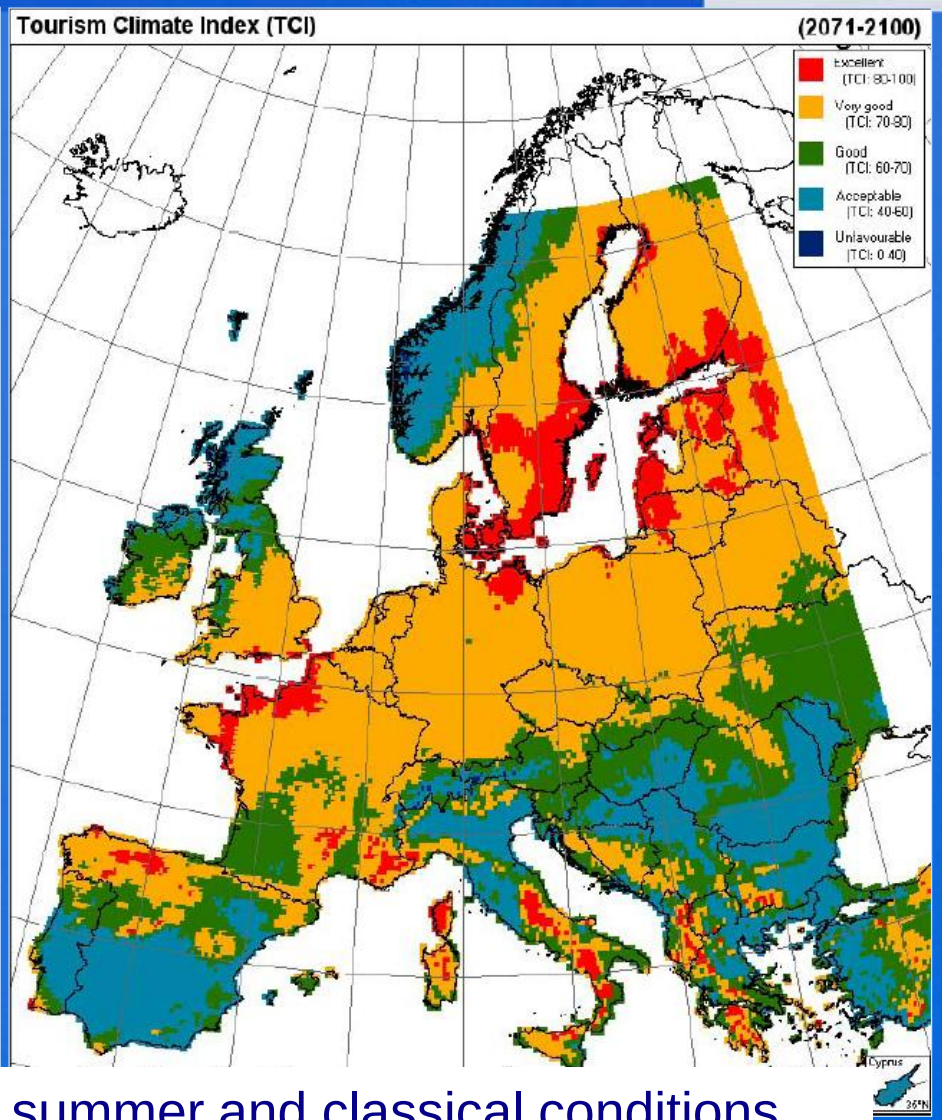
Each parameter is weighted,
Each parameter can reach 5 points
→ TCI maximum score of 100

| | |
|---|---|
| ***< 40*** | ***unfavorable or difficult conditions for tourism*** |
| ***40 – 59*** | ***moderate, acceptable conditions*** |
| ***60 – 79*** | ***good – very good conditions*** |
| ***≥ 80*** | ***excellent conditions*** |

# Tourism Climate Index (TCI)






- Only summer and classical conditions
- Thermal comfort not based on HEB
- Not quantified

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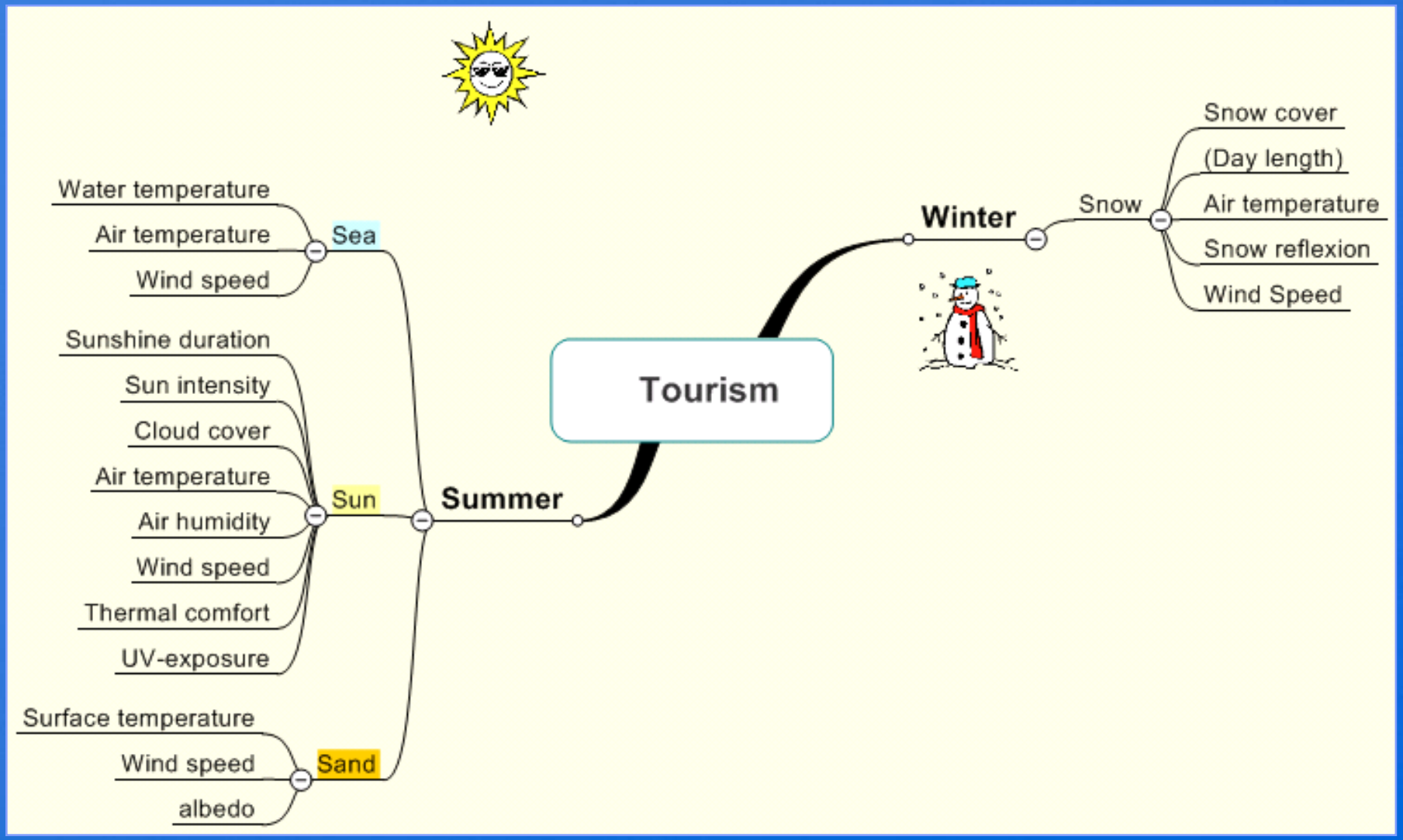
# Different views: Climatology and Tourism
# Climate parameters relevant for tourism (selection)




(Matzarakis, 2006)

# Facets of climate in tourism



| Aesthetic | Physical | Thermal |
|---|---|---|
| *Sunshine duration* | *Wind* | *Synergetic effects of air temperature, wind velocity, relative humidity, long- und short wave radiation, metabolism, activity, clothing* |
| *Visibility* | *Rain* | |
| *Fog* | *Snow/Ice* | |
| *Length of day* | *Extreme Weather* | |
| | *Air quality* | |
| | *UV* | |
| | *Odors/Noise* | |
| **Attractiveness, Enjoyment** | **Annoyance, danger, activity, …** | **Thermal comfort/stress** |



(from de Freitas 2003, Matzarakis 2006; modified)

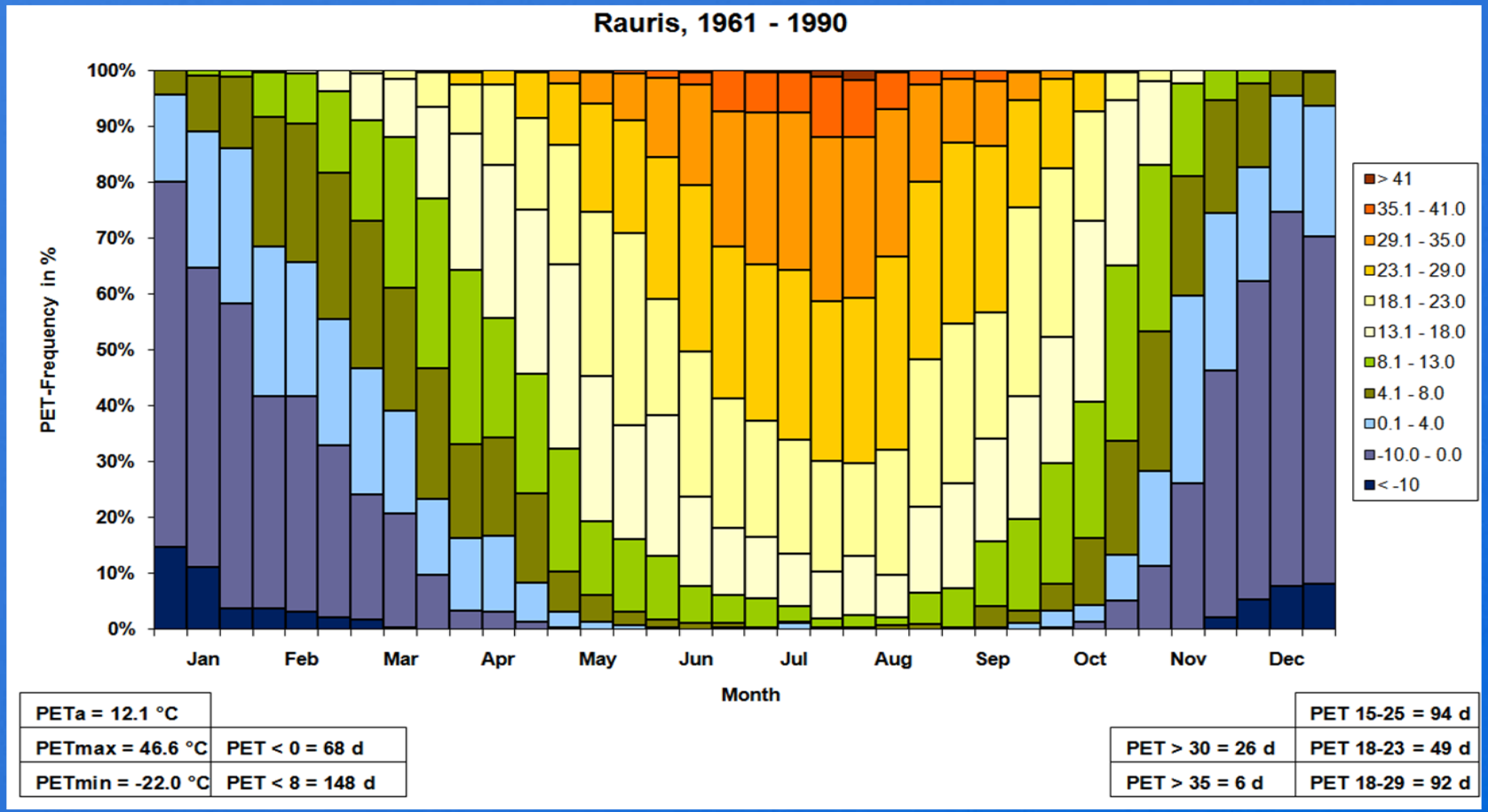
# The analyzed locations




*(The red frame shows the location corresponding to the following diagrams.)*

# Physiologically Equivalent Temperature (PET)

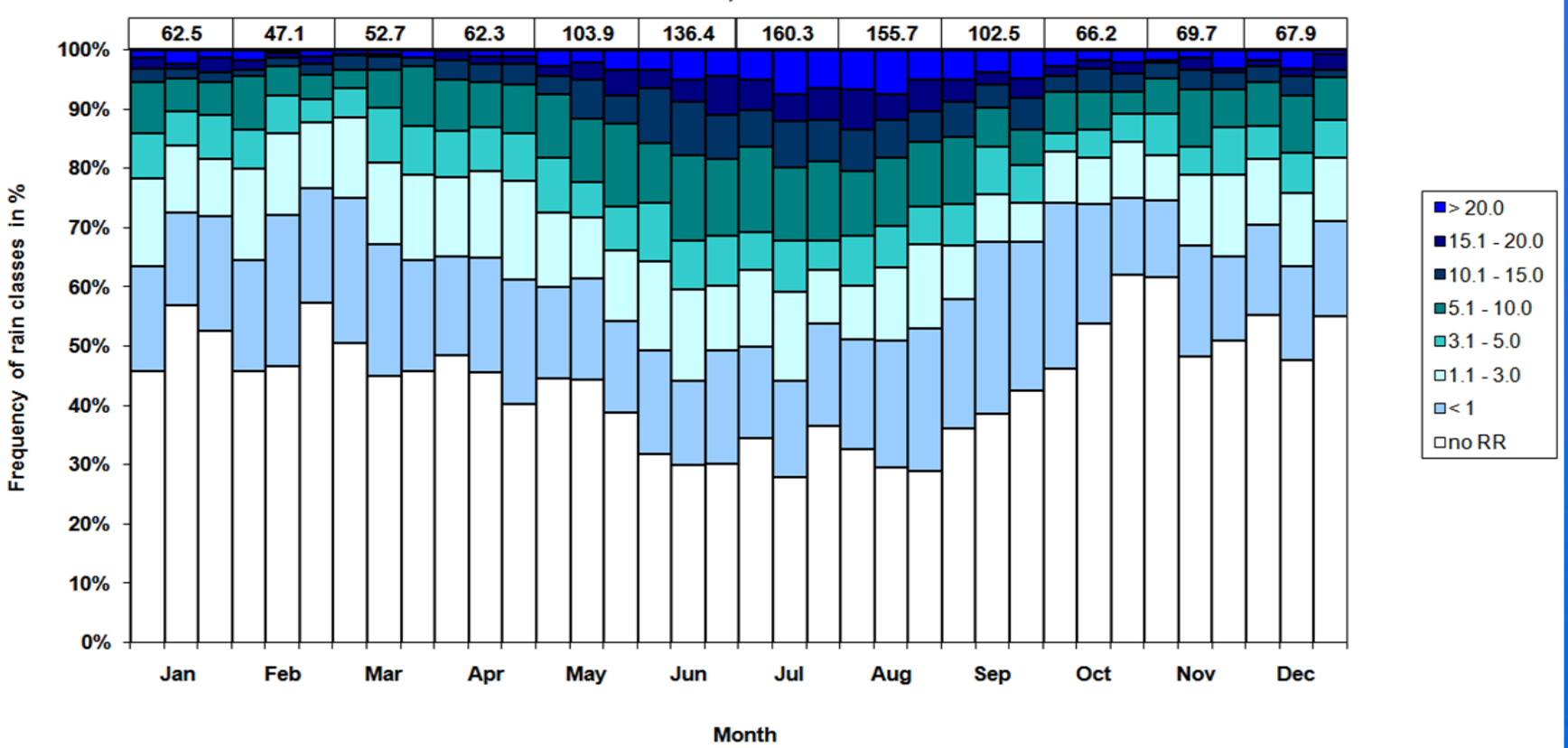
PET-frequency diagram for Rauris (period: 1961-1990), plotted in 10-day-intervals (monthly decades) from January to December.



# Precipitation, cloud cover etc.



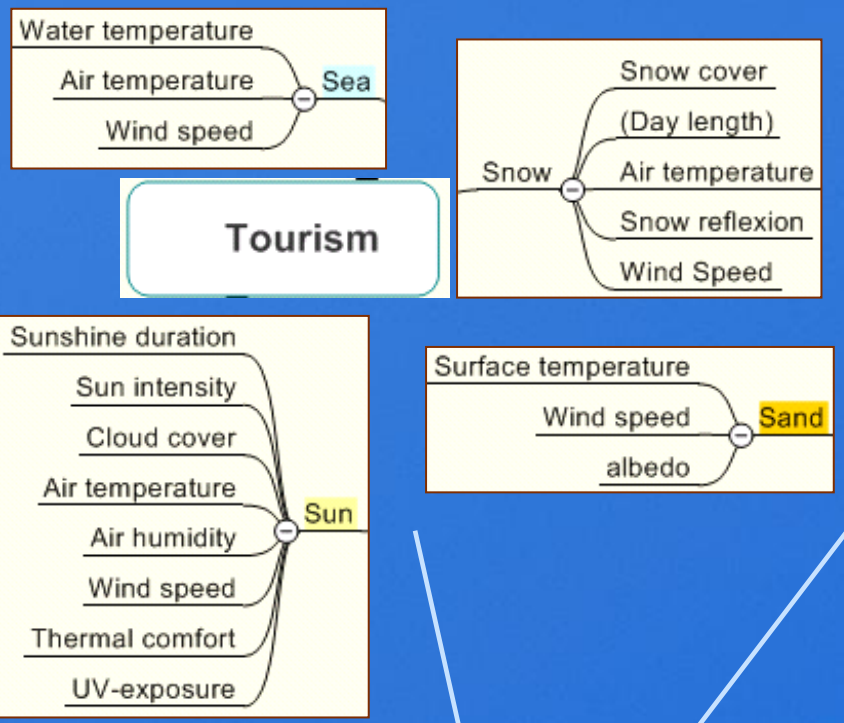
Precipitation-frequency diagram for Rauris(period 1961-1990), plotted in 10-day intervals from January to December




| | | |
|---|---|---|
| RRa = 1087.1 mm | RR > 5 mm = 66 d | RR < 1 mm = 231 d |
| RRmax = 95.6 mm | SN > 10 = 80 d | SN > 30 = 29 d |

| | |
|---|---|
| Cloud < 4 = 144 d | VP > 18 hPa = 1 d |
| RH > 93 % = 5 d | Wind > 8 m/s = 0 d |

# Climate Tourism/Transfer Information Scheme




thermal

physical

aesthetic

Leisure/Recreation - activities Ressorts etc.

Tourists and Tourism industry

Quantification/ Assessment/ Analysis of Destinations/ Target group

Climate-Tourism/Transfer-Information-Scheme

# CTIS



- **The Climate-Tourism/Transfer-Information-Scheme is based on:**
- Basic climate parameters ((air temperature, air humidity not direct), wind velocity, cloud cover, precipitation) in daily values,
- Temporal information in **monthly decades** (division of the month in three intervals),
- Incorporation of climatological and human-biometeorological conditions which base on **frequencies and threshold values**,
- Incorporation of thermal comfort (PET), heat stress, cold stress and sultriness,
- Incorporation of precipitation (type and amount) as influencing factor,
- Incorporation of fog, abundance of sun and/or clouds,
- Incorporation of windy conditions.

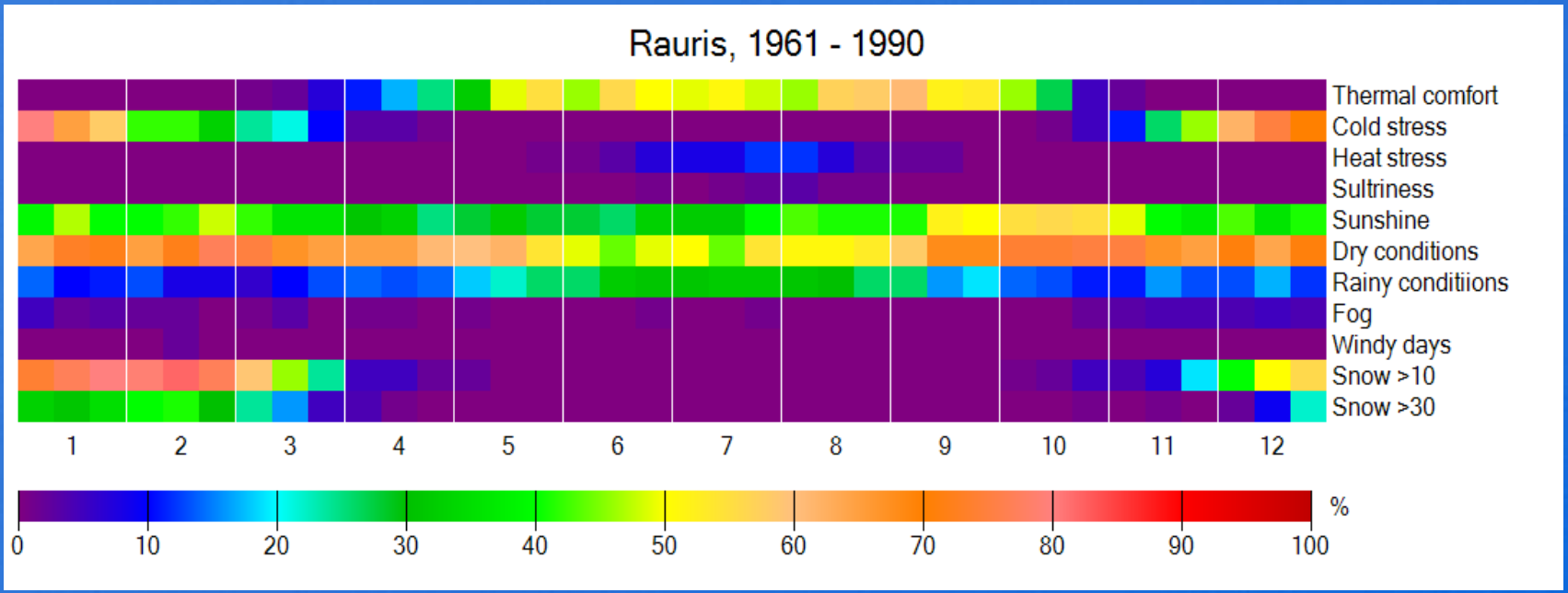
# Analyzed parameters and their threshold values

| | |
|---|---|
| ➢ Thermal comfort | (18 °C < *PET < 29 °C) |
| ➢ Heat stress | (*PET > 35 °C) |
| ➢ Cold stress | (*PET < 0 °C) |
| ➢ Sunshine | (cloud cover < 5/8) |
| ➢ Fog | (relative humidity > 93 %) |
| ➢ Hot-humid, sultriness | (vapor pressure > 18 hPa) |
| ➢ Day without rain | (precipitation ≤ 1 mm) |
| ➢ Rainy day | (precipitation > 5 mm) |
| ➢ Day with stormy weather | (wind velocity > 8 m/s) |
| ➢ (Skiing potential) | [snow cover > 10 cm /30 cm]) |

**** PET = Physiologically Equivalent Temperature***

# CTIS

Climate-Tourism-Information-Scheme (CTIS) for Rauris for the period 1961-1990, plotted in monthly decades from January to December



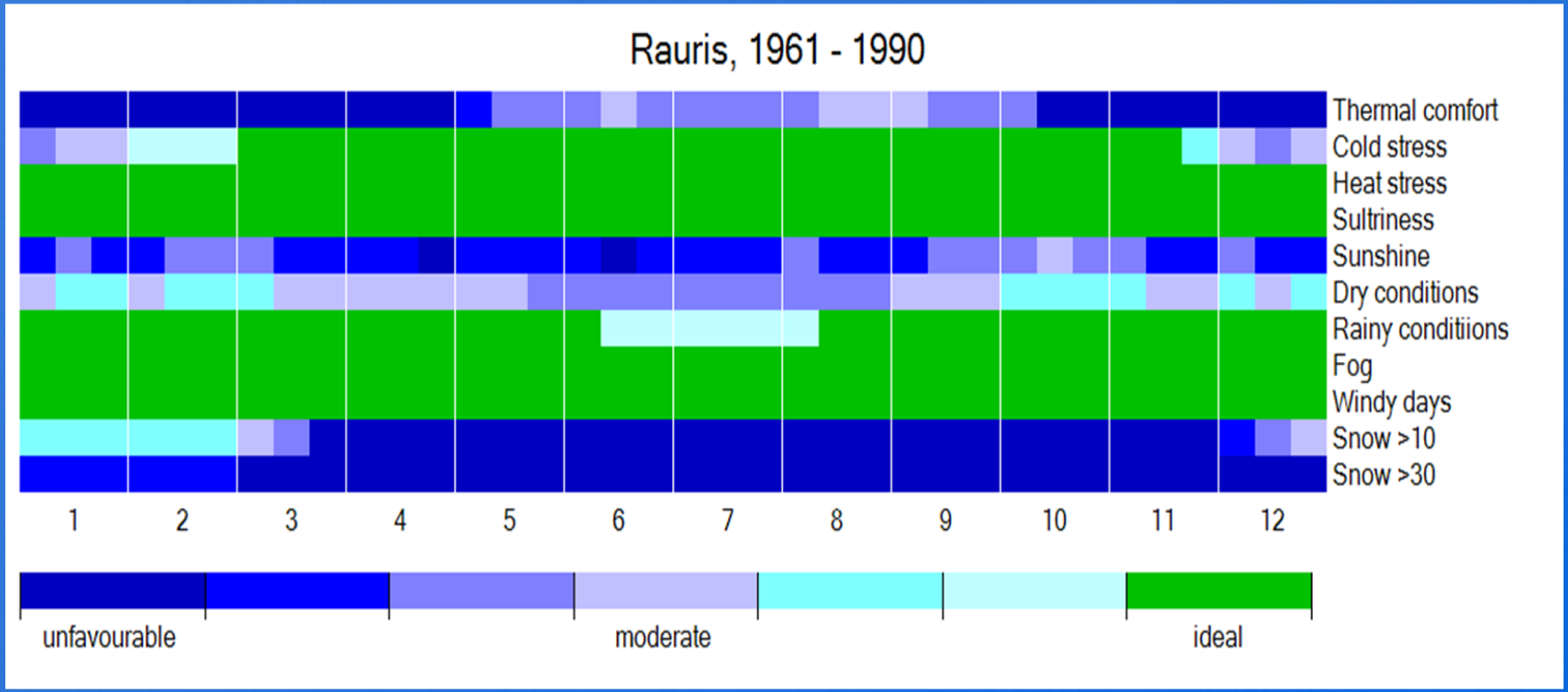

Percent-type of plotting (frequency of the parameter in each monthly decade = each 10-day-interval)

# Scale for assessment (rating)

| color | range of per cent values | description |
|---|---|---|
| | < 14% | unfavorable |
| | 14 % - 28 % | ↕ |
| | 28 % - 42 % | ↕ |
| | 42 % - 56 % | moderate |
| | 56 % - 70 % | ↕ |
| | 70 % - 84 % | ↕ |
| | > 84 % | ideal |

# CTIS

Climate-Tourism-Information-Scheme (CTIS) for Rauris for the period 1961-1990, plotted in monthly decades from January to December

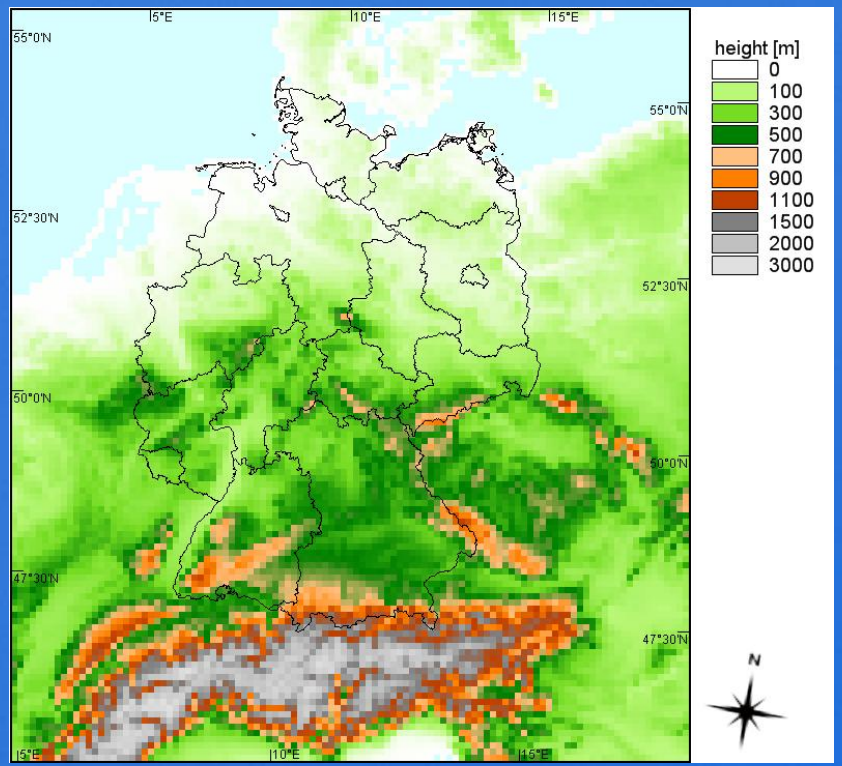



„Assessment“-type (rated CTIS)

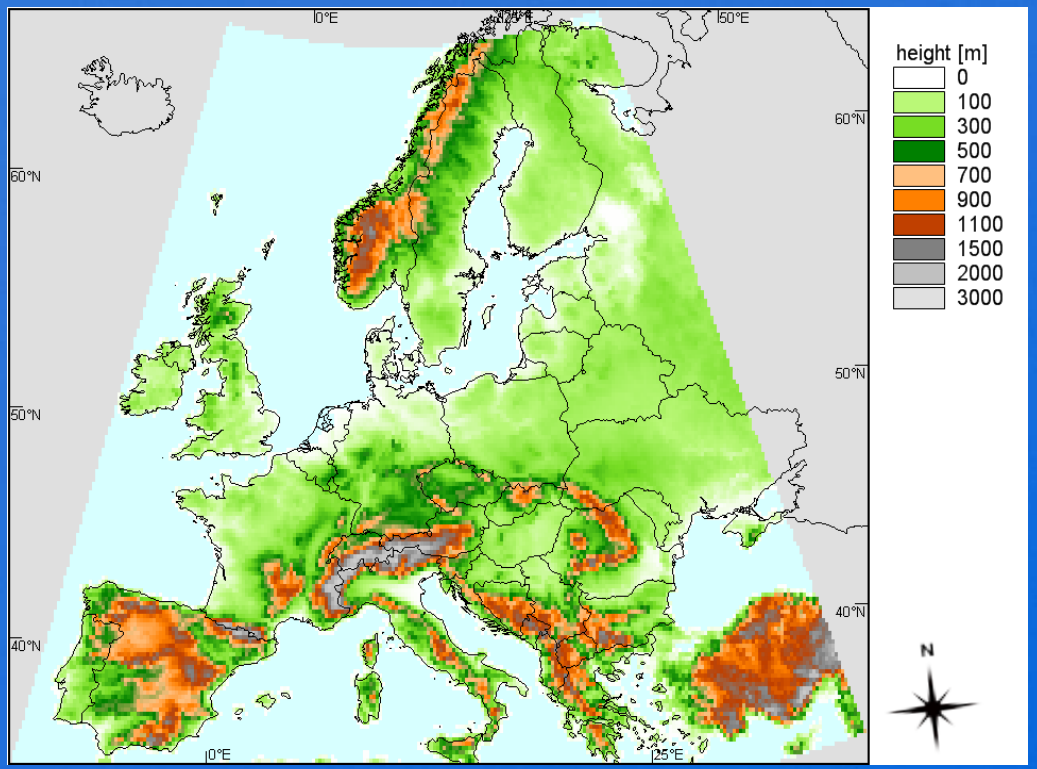
# Used climate model data

## Methods and Data: Regional climate models

### REMO (~10 km)

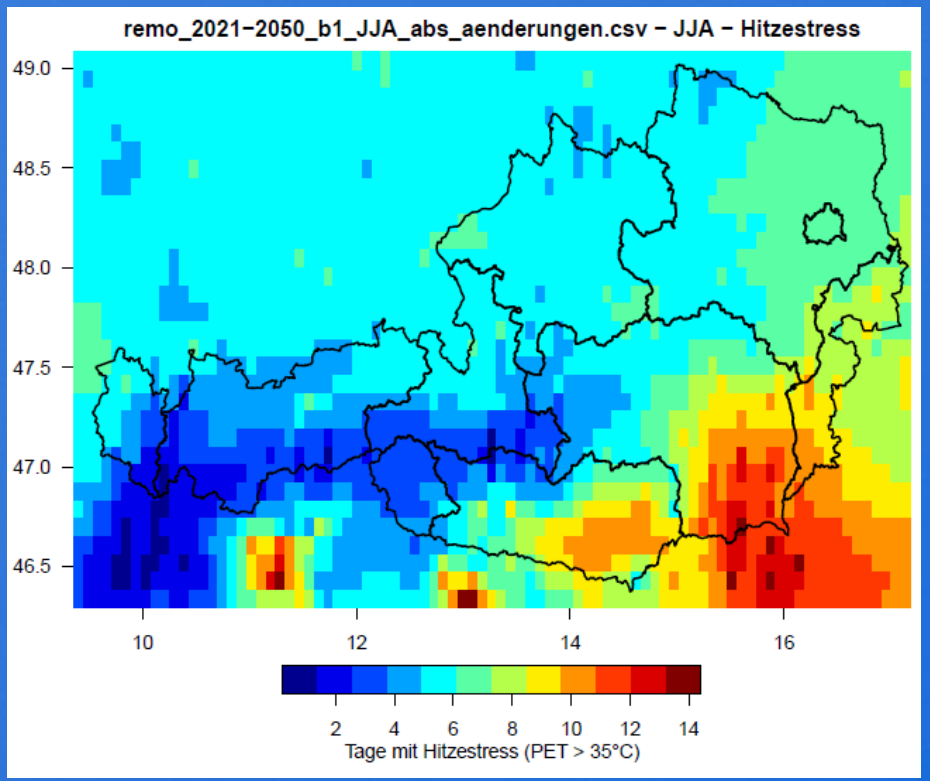



### CLM (~18 km)

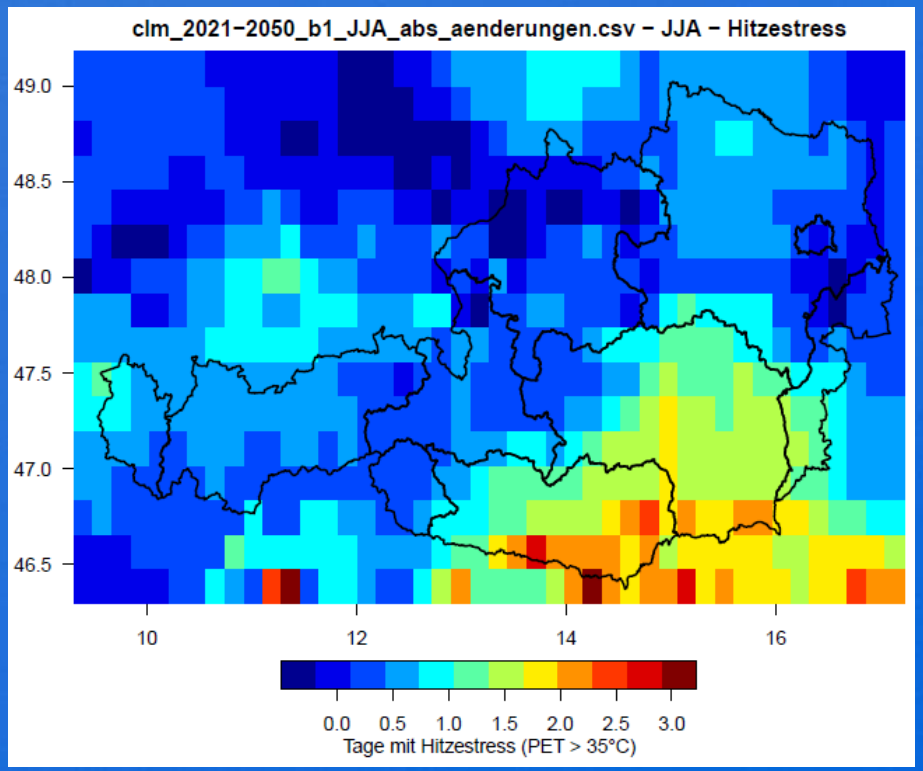


# Maps creation of CTIS-Factors

Number of additional days with heat stress in summer in Austria. Comparison between periods 1971 – 2000 and 2021 – 2050, scenario B1.




REMO




CLM

# Qualitative assessment

Qualitative assessment for the **whole area** of Austria (period: 2071 – 2100)

| Parameter | CLM | | REMO | | Tendency |
|---|---|---|---|---|---|
| *Thermal comfort* | A1B: ++ | B1: + | A1B: + | B1: + | moderate increase (+) |
| | + | | + | | |
| *Cold stress* | A1B: - - | B1: - - | A1B: - - | B1: - - | distinct decrease (- -) |
| | - - | | - - | | |
| *Heat stress* | A1B: ++ | B1: + | A1B: + | B1: + | moderate increase (+) |
| | + | | + | | |
| *Sultriness* | A1B: + | B1: + | A1B: ++ | B1: ++ | moderate increase (+) |
| | + | | ++ | | |
| *Dry conditions* | A1B: - | B1: - | A1B: + | B1: + | no tendency (0) |
| | - | | + | | |
| *Rainy conditions* | A1B: + | B1: + | A1B: - | B1: - | no tendency (0) |
| | + | | - | | |
| *Skiing potential* | A1B: - - | B1: - - | A1B: - - | B1: - - | distinct decrease (- -) |
| | - - | | - - | | |
| *Windy days* | A1B: 0 | B1: 0 | A1B: + | B1: 0 | no tendency (0) |
| | 0 | | 0 | | |
| *Sunshine* | A1B: + | B1: + | NIL | NIL | moderate increase (+) |
| | + | | NIL | | |
| *Fog* | A1B: - - | B1: - | A1B: 0 | B1: + | moderate decrease (-) |
| | - | | 0 | | |

*Classes for the qualitative assessment (according to Endler und Matzarakis 2010 S. 160f)*

* Used for „Sunshine“ in REMO because the model does not offer this parameter.

| Symbol | Degree of change |
|---|---|
| - - | distinct decrease |
| - | moderate decrease |
| 0 | no tendency |
| + | moderate increase |
| ++ | distinct increase |
| NIL* | (no data) |

# Qualitative assessment

## Qualitative assessment for the **lower areas** of Austria (period: 2071 – 2100)

| Parameter | CLM | | REMO | | Tendency |
|---|---|---|---|---|---|
| *Thermal comfort* | A1B: 0 | B1: 0 | A1B: 0 | B1: 0 | no tendency (0) |
| | 0 | | 0 | | |
| *Cold stress* | A1B: - - | B1: - - | A1B: - - | B1: - - | distinct decrease (- -) |
| | - - | | - - | | |
| *Heat stress* | A1B: ++ | B1: + | A1B: ++ | B1: + | moderate increase (+) |
| | + | | + | | |
| *Sultriness* | A1B: ++ | B1: + | A1B: ++ | B1: ++ | distinct increase (++) |
| | + | | ++ | | |
| *Dry conditions* | A1B: + | B1: 0 | A1B: + | B1: + | moderate increase (+) |
| | 0 | | + | | |
| *Rainy conditions* | A1B: + | B1: + | A1B: 0 | B1: 0 | moderate increase (+) |
| | + | | 0 | | |
| *Skiing potential* | A1B: - - | B1: - - | A1B: - - | B1: - - | distinct decrease (- -) |
| | - - | | - - | | |
| *Windy days* | A1B: 0 | B1: 0 | A1B: + | B1: 0 | no tendency (0) |
| | 0 | | 0 | | |
| *Sunshine* | A1B: + | B1: 0 | k. A. | k. A. | no tendency (0) |
| | 0 | | k. A. | | |
| *Fog* | A1B: 0 | B1: 0 | A1B: 0 | B1: 0 | no tendency (0) |
| | 0 | | 0 | | |

*Classes for the qualitative assessment (according to Endler und Matzarakis 2010 S. 160f)*

* Used for „Sunshine“ in REMO because the model does not offer this parameter.

| Symbol | Degree of change |
|---|---|
| - - | distinct decrease |
| - | moderate decrease |
| 0 | no tendency |
| + | moderate increase |
| ++ | distinct increase |
| NIL* | (no data) |

# Qualitative assessment

Qualitative assessment for the **higher areas** of Austria (period: 2071 – 2100)

| Parameter | CLM | | REMO | | Tendency |
|---|---|---|---|---|---|
| *Thermal comfort* | A1B: ++ | B1: ++ | A1B: + | B1: + | moderate increase (+) |
| | ++ | | + | | |
| *Cold stress* | A1B: - - | B1: - - | A1B: - - | B1: - - | distinct decrease (- -) |
| | - - | | - - | | |
| *Heat stress* | A1B: + | B1: 0 | A1B: + | B1: 0 | no tendency (0) |
| | 0 | | 0 | | |
| *Sultriness* | A1B: + | B1: + | A1B: + | B1: + | moderate increase (+) |
| | + | | + | | |
| *Dry conditions* | A1B: - - | B1: - | A1B: ++ | B1: + | no tendency (0) |
| | - | | + | | |
| *Rainy conditions* | A1B: + | B1: + | A1B: - | B1: - | no tendency (0) |
| | + | | - | | |
| *Skiing potential* | A1B: - - | B1: - - | A1B: - - | B1: - - | distinct decrease (- -) |
| | - - | | - - | | |
| *Windy days* | A1B: 0 | B1: 0 | A1B: + | B1: 0 | no tendency (0) |
| | 0 | | 0 | | |
| *Sunshine* | A1B: ++ | B1: + | k. A. | k. A. | moderate increase (+) |
| | + | | k. A. | | |
| *Fog* | A1B: - - | B1: - | A1B: + | B1: 0 | moderate decrease (-) |
| | - | | 0 | | |

*Classes for the qualitative assessment (according to Endler und Matzarakis 2010 S. 160f)*

* Used for „Sunshine“ in REMO because the model does not offer this parameter.

| Symbol | Degree of change |
|---|---|
| - - | distinct decrease |
| - | moderate decrease |
| 0 | no tendency |
| + | moderate increase |
| ++ | distinct increase |
| NIL* | (no data) |

# Summary



- Analysis for the whole year!
- High temporal resolution (CTIS)
- Maps of important CTIS-parameters (periods 1961-1990, 2021-2050, 2071-2100) from REMO- and COSMO-CLM-runs
- Summarizing and quantitative assessment of REMO/CLM-results
- Basics first, then climate change
- Winners and losers! – Focus also on other climate- and tourism-regions
- Flexibility of the travelers (tourists) and providers (tourism industry)

# Thank you for your attention