Evaluation of solar irradiance azimuthal dependence over Thessaloniki

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Intro

Question

> **Is there an asymmetry on the
> measured irradiance
> around South-North direction
> over Thessaloniki?**

Broadband Instruments

CHP-1

- Beam irradiance (DNI)
- Tracking the sun
- 200nm - 4000nm

CM-21

- Global irradiance (GLB)
- Viewing the "whole" sky
- 335nm - 2200nm

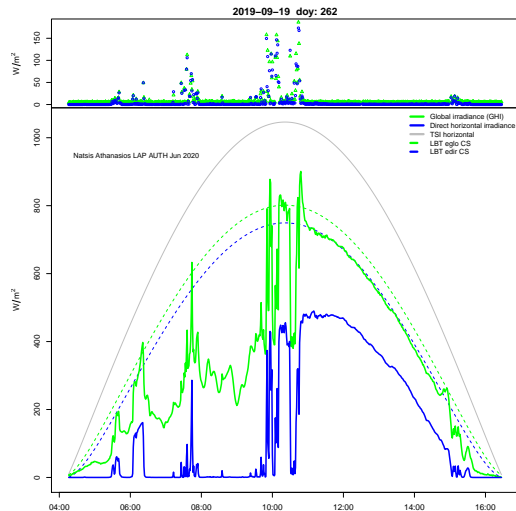# Data for this work

Variables

- Data span: 2016 - 2019
- CHP-1: Beam irradiance (DNI) ($Watt/m^2$)
- CM-21: Diffuse irradiance (DHI) ($Watt/m^2$)

    $$DHI = GHI - DNI \cdot coz(z)$$

Main data process steps

- Initial measurements
    - Manual inspection
        * Quality control checks and filtering
          An Automated Quality Assessment and Control Algorithm for Surface Radiation Measurements, C. N. Long, Y. Shi, 2008
            > "Clear sky" identification
              Identification of periods of clear sky irradiance in time series of GHI measurements, Matthew J. Reno, Clifford W. Hansen, 2016
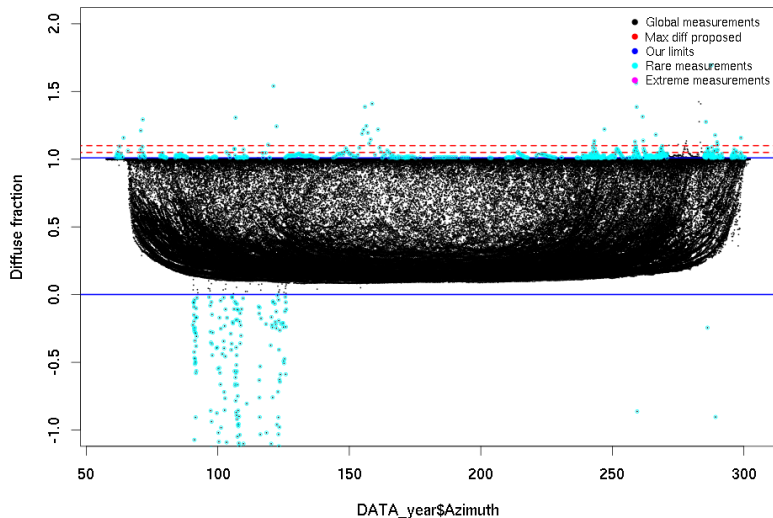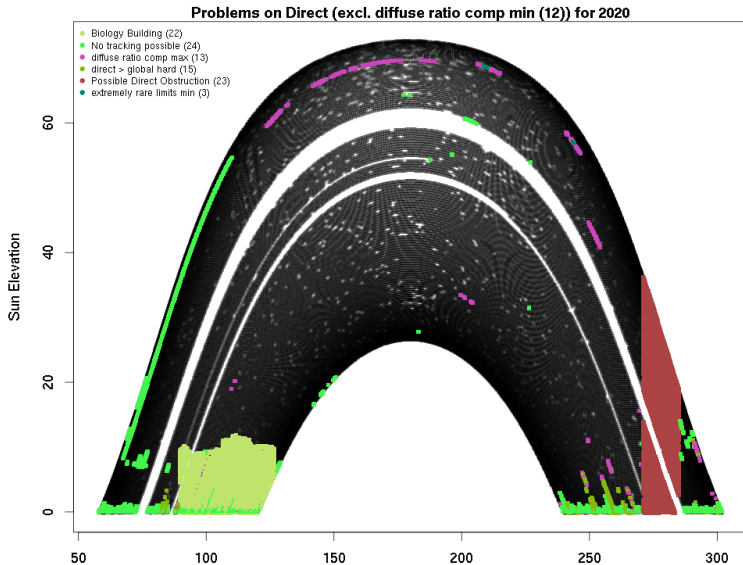
Measurements

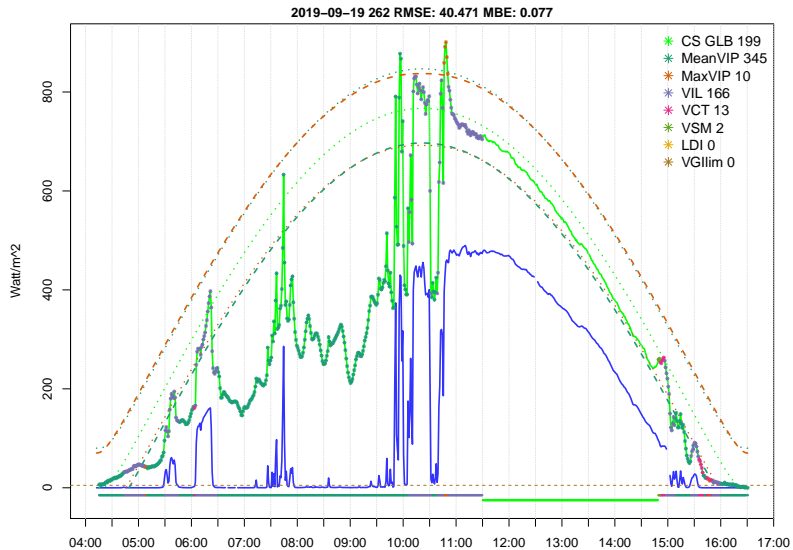From voltage to watt...

Quality control, Physical limits

Comparison test 3. 2018

Quality control, erroneous data

Problems on Direct (excl. diffuse ratio comp min (12)) for 2020

Legend:
- Biology Building (22)
- No tracking possible (24)
- diffuse ratio comp max (13)
- direct > global hard (15)
- Possible Direct Obstruction (23)
- extremely rare limits min (3)

Y-axis: Sun Elevation

Clear sky id

2019−09−19 262 RMSE: 40.471 MBE: 0.077

Analysis

Key concepts

- Bin data by:
    - Azimuth angle
    - Zenith/Elevation angle
    - Month
- Compute the average irradiance in each bin
    - The whole 4 year period
    - The same month of all years
- We present the **difference of averages** for **symmetric sky location** around North-South axis
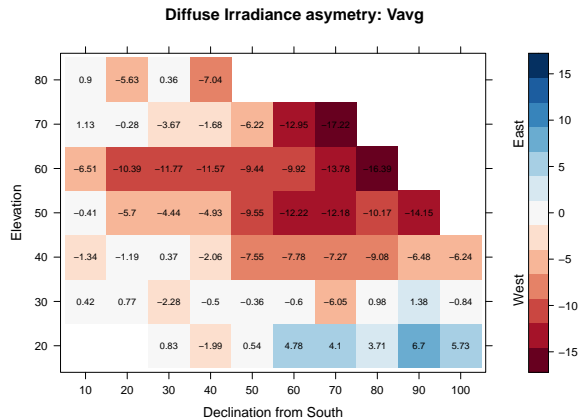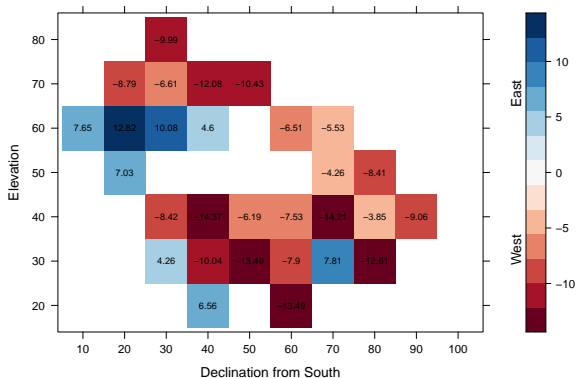
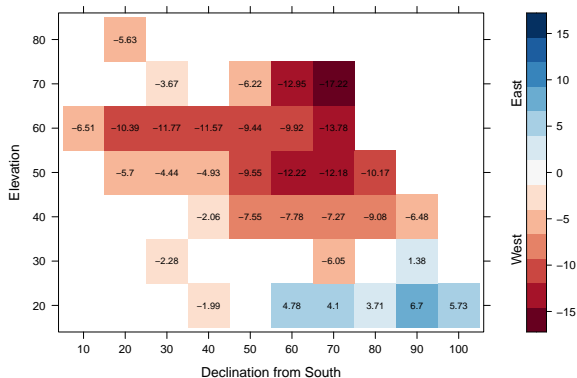# Results

Difference of averages no constrains
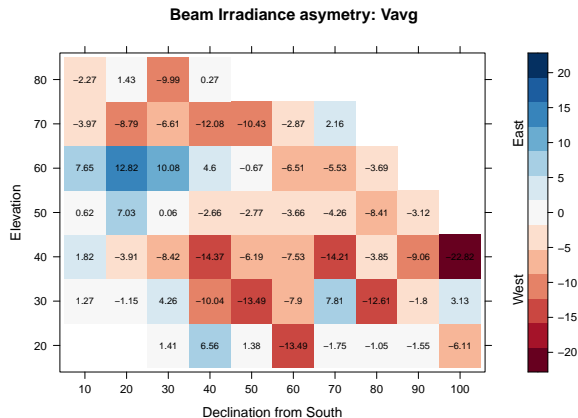
Beam

Diffuse

Results

Difference of averages with high statistical significance (**$p < 0.05$**) and relative **difference of the sample size $< 30\%$**

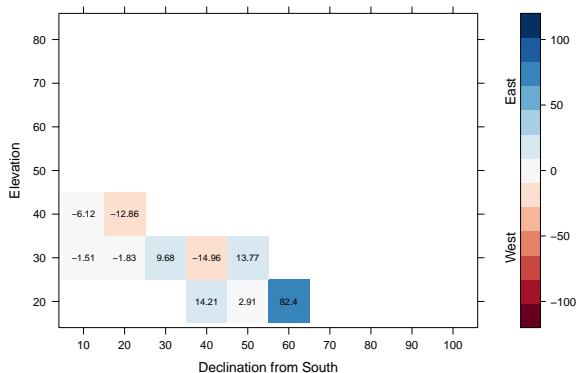Beam Irradiance asymetry: Vavg p < 0.05 relN < 0.3 · Diffuse Irradiance asymetry: Vavg p < 0.05 relN < 0.3

Seasonal aspect

January Difference of averages no constrains

Beam   **Diffuse**

Beam Irradiance asymmetry: Vavg Month: 1

Diffuse Irradiance asymmetry: Vavg Month: 1
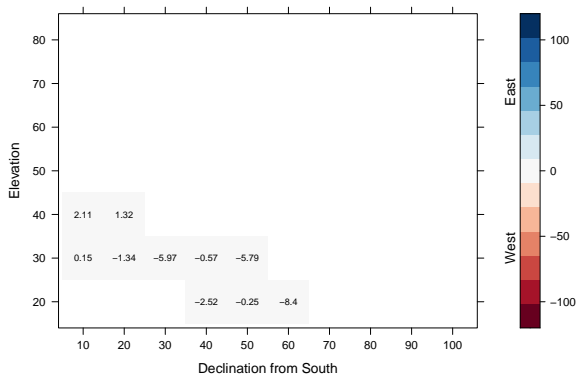
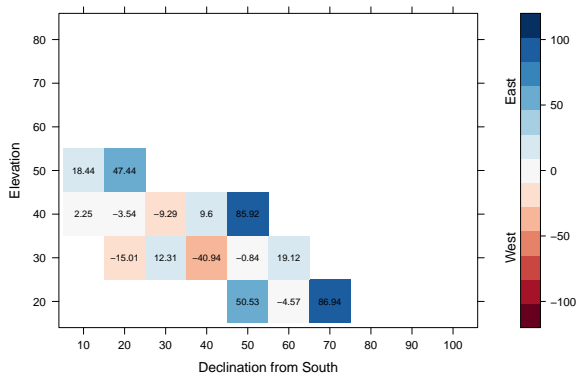# Seasonal aspect

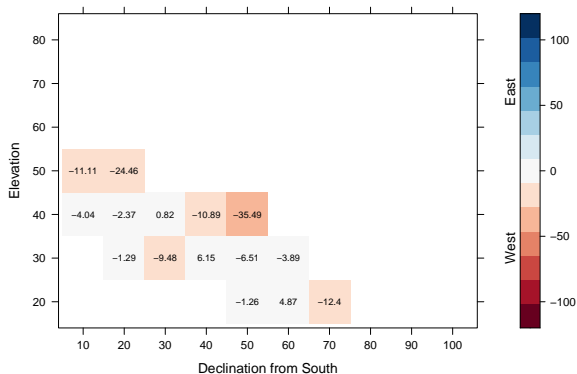**February** Difference of averages no constrains

Beam   **Diffuse**

Beam Irradiance asymmetry: Vavg Month: 2

Diffuse Irradiance asymmetry: Vavg Month: 2
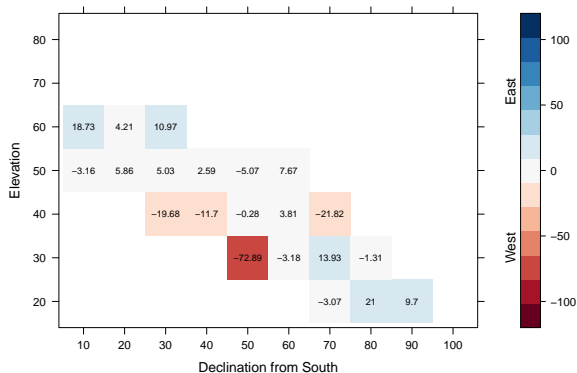
Seasonal aspect
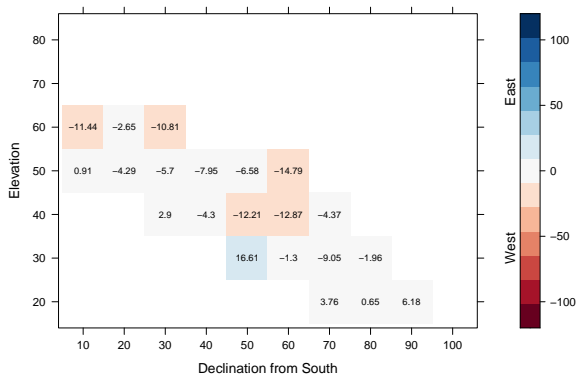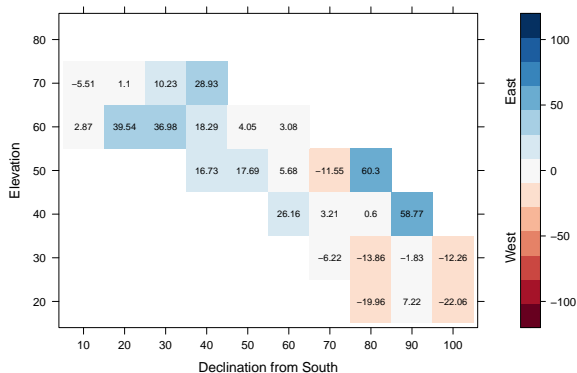
March Difference of averages no constrains

Beam   **Diffuse**

Beam Irradiance asymetry: Vavg Month: 3

Diffuse Irradiance asymetry: Vavg Month: 3

Seasonal aspect
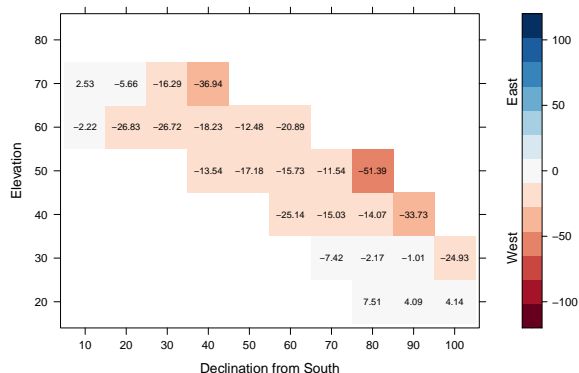
April Difference of averages no constrains

Beam   **Diffuse**

Beam Irradiance asymetry: Vavg Month: 4
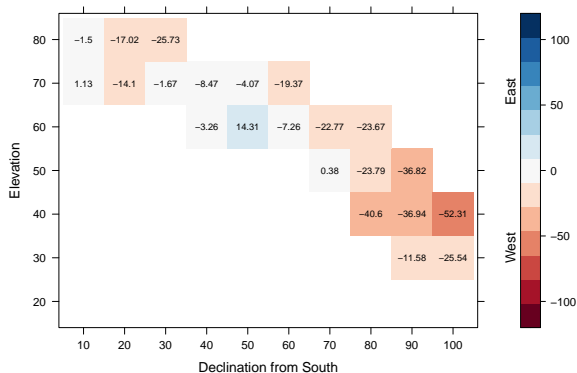

Diffuse Irradiance asymetry: Vavg Month: 4
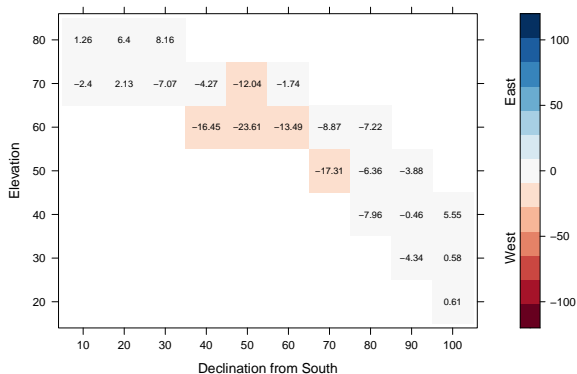
Seasonal aspect

May Difference of averages no constrains

Beam   **Diffuse**

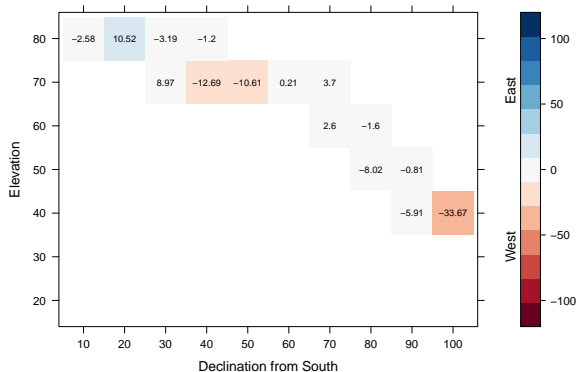# Seasonal aspect

June Difference of averages no constrains

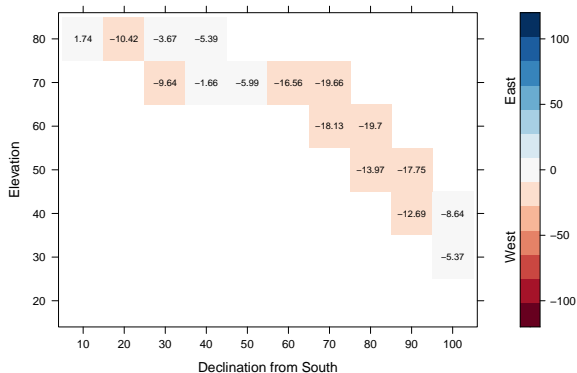**Beam**   **Diffuse**

Beam Irradiance asymmetry: Vavg Month: 6

Diffuse Irradiance asymmetry: Vavg Month: 6
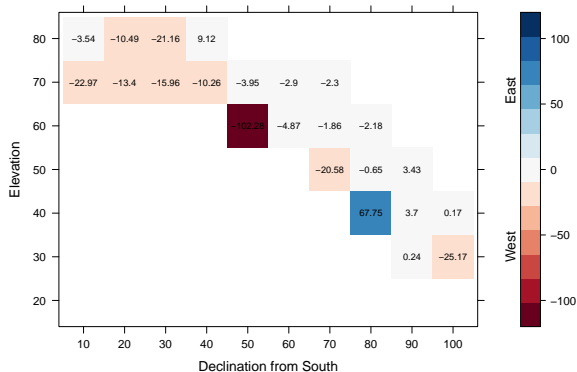
Seasonal aspect

July Difference of averages no constrains

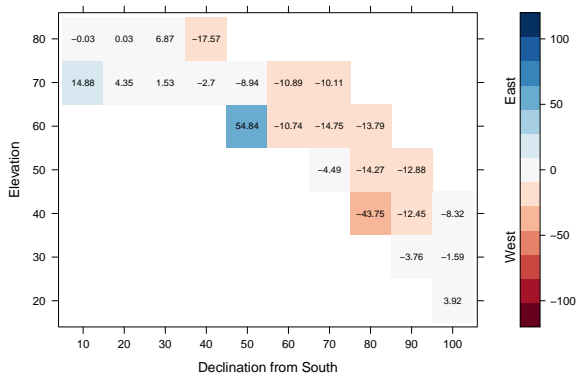**Beam**   **Diffuse**

Beam Irradiance asymetry: Vavg Month: 7

Diffuse Irradiance asymetry: Vavg Month: 7
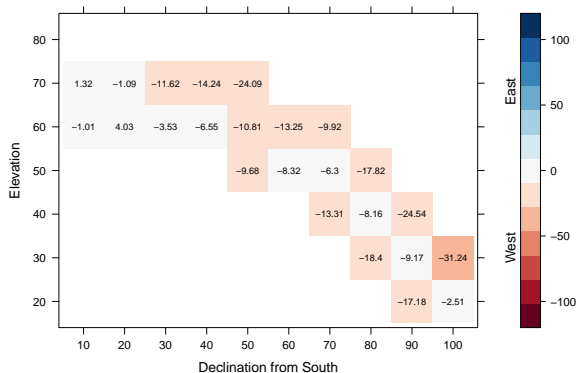
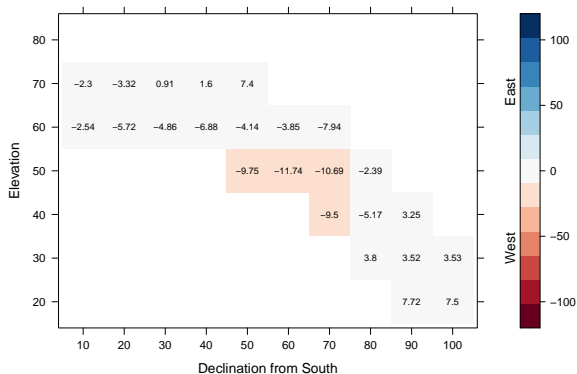# Seasonal aspect

August Difference of averages no constrains

Beam

Diffuse

Beam Irradiance asymetry: Vavg Month: 8

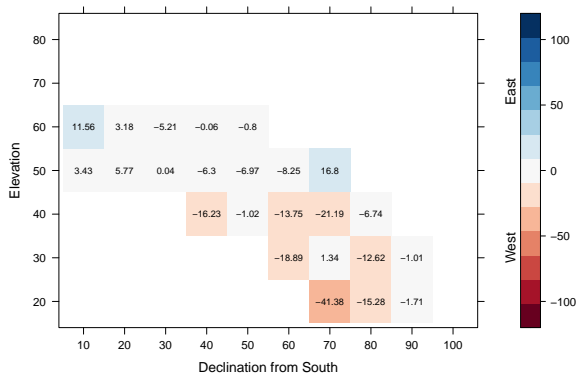Diffuse Irradiance asymetry: Vavg Month: 8

Seasonal aspect

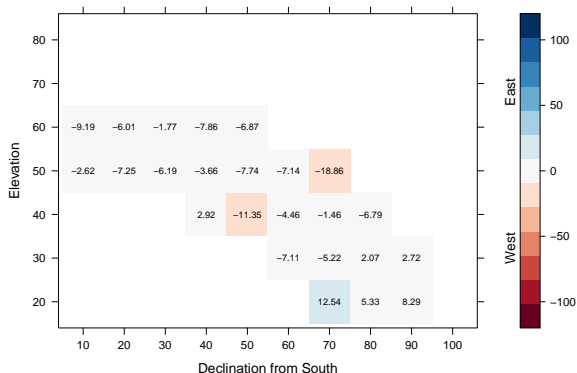**September** Difference of averages no constrains

Beam   **Diffuse**

Beam Irradiance asymetry: Vavg Month: 9

Diffuse Irradiance asymetry: Vavg Month: 9

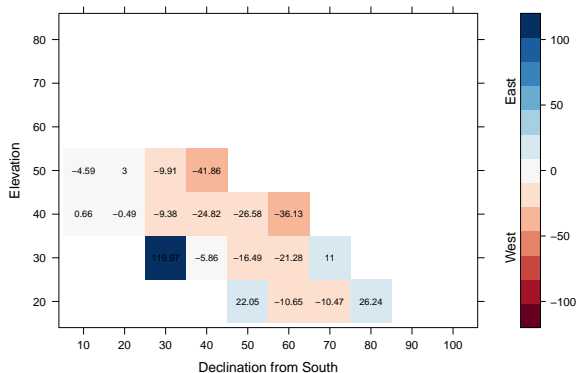# Seasonal aspect

October Difference of averages no constrains
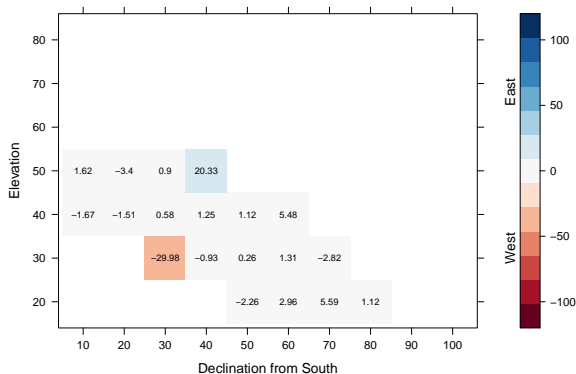
Beam   **Diffuse**

Beam Irradiance asymetry: Vavg Month: 10

Diffuse Irradiance asymetry: Vavg Month: 10

Seasonal aspect

November Difference of averages no constrains

Beam   **Diffuse**

Beam Irradiance asymetry: Vavg Month: 11

Diffuse Irradiance asymetry: Vavg Month: 11
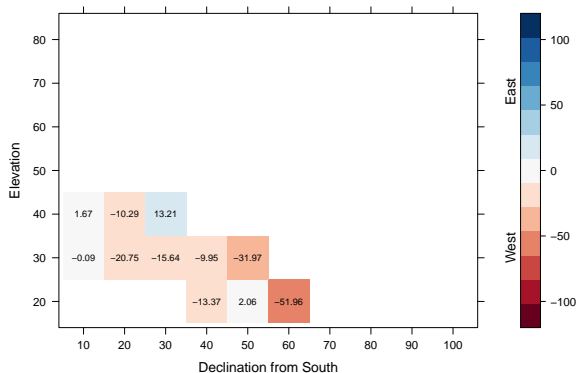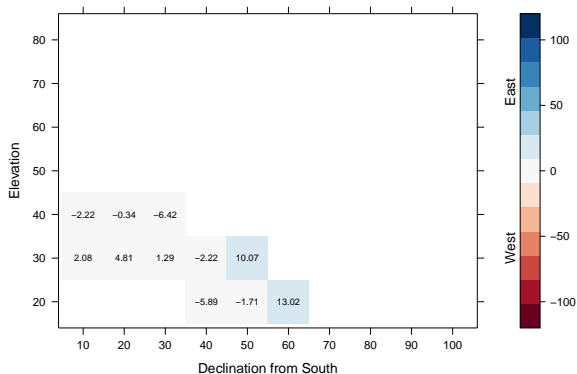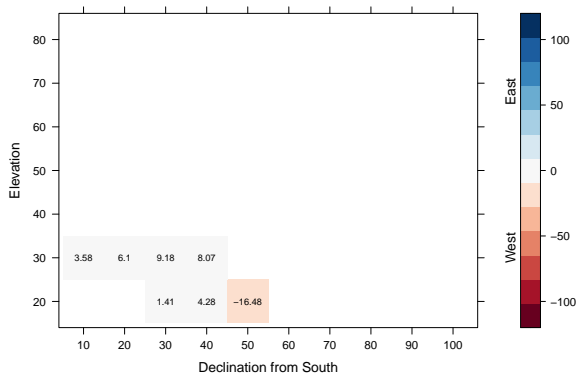
Seasonal aspect

December Difference of averages no constrains
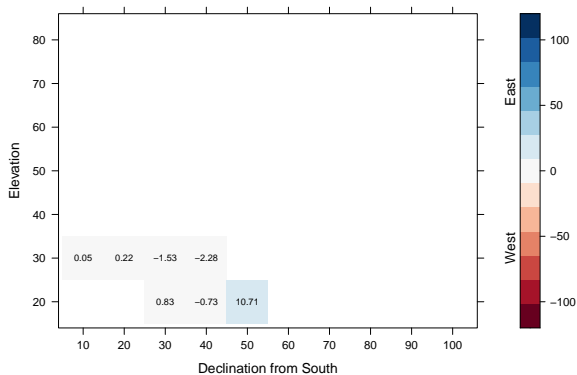
Beam   **Diffuse**

Beam Irradiance asymetry: Vavg Month: 12

Diffuse Irradiance asymetry: Vavg Month: 12

Conclusions

West part of the sky greater values of mean irradiance

- Valid for Diffuse, Direct and Global component
- For the 4-year period

The balance can change during the year

- Using only sza when analyzing this data may hide some information
- Representation issues exist when generalizing

Diffuse and Direct irradiance bias shows a complementary distribution

- It's a calculation artifact?
- Which mechanisms attenuate these results?

Thank you!

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