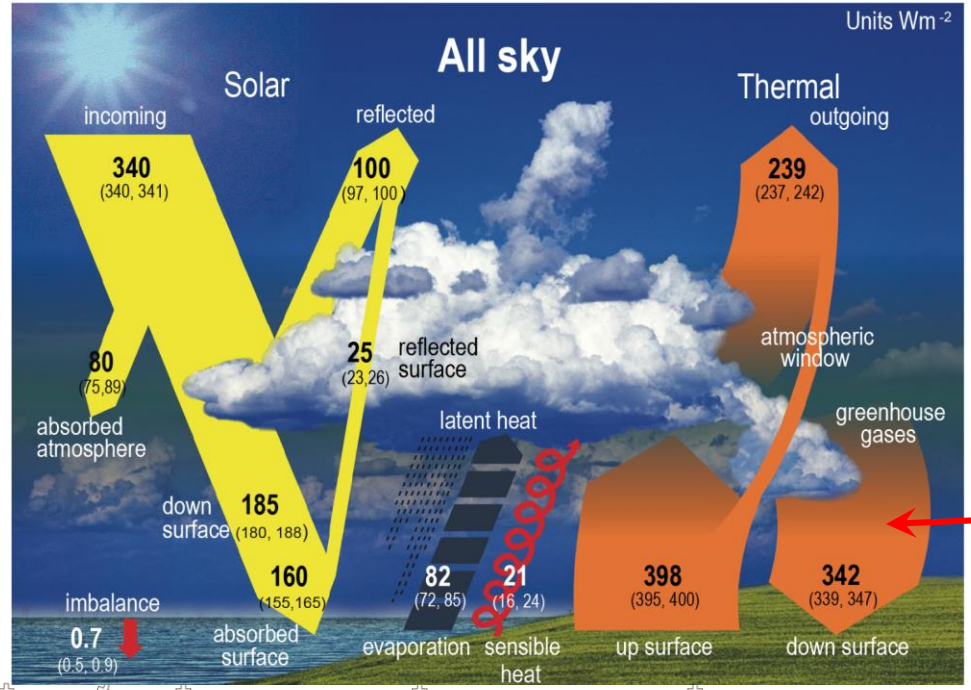
IR↓ radiation: a diagnostic tool of climate change



From Forster et al. 2021, IPCC AR6, Vol. 1, Ch. 7.

Radiation imbalance =
climate change engine

GHG concentration increase

?

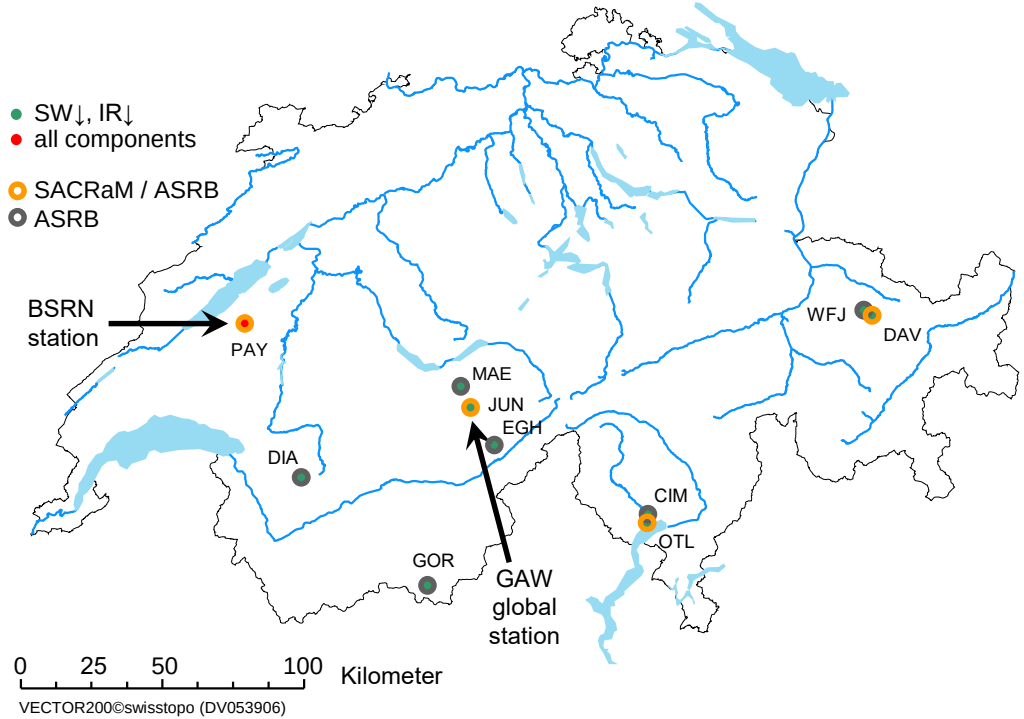
Downward IR↓ radiation increase

IR↓ radiation trends in Switzerland

Nyeki et al. (2019). Trends in surface radiation and cloud radiative effect at four Swiss sites for the 1996–2015 period. Atmos. Chem. Phys., 19, doi: 10.5194/acp-19-13227-2019

- 20-year IR↓ monitoring at 4 stations
- IR↓ & SW global (visible) gathered from two networks
  - ASRB ~1995 → ~2011
  - SACRaM ~1993-2000 →…

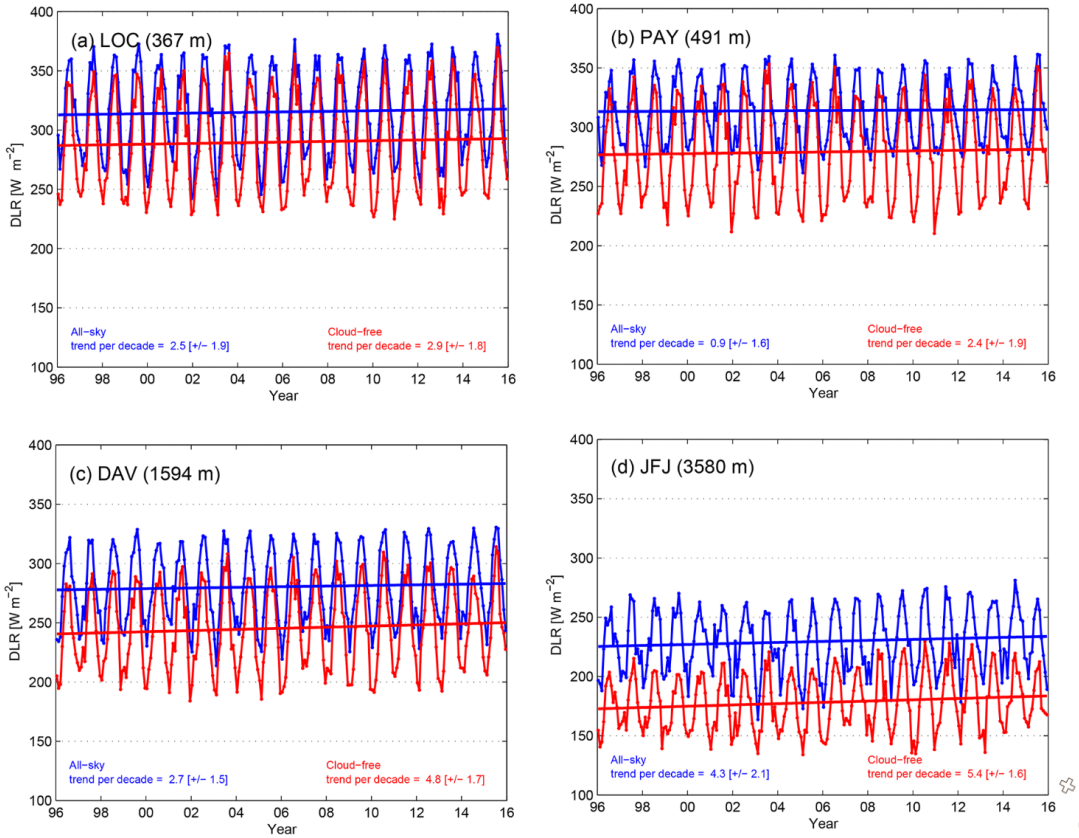
SACRaM and ASRB network stations



IR↓ radiation trends in Switzerland

Nyeki et al. (2019). Trends in surface radiation and cloud radiative effect at four Swiss sites for the 1996–2015 period. Atmos. Chem. Phys., 19, doi: 10.5194/acp-19-13227-2019

- 20-year IR↓ monitoring at 4 stations
- All trends positive and all but 1 significant at 90% CL
- Considering only clear-sky data (red) → stronger trends



Summary

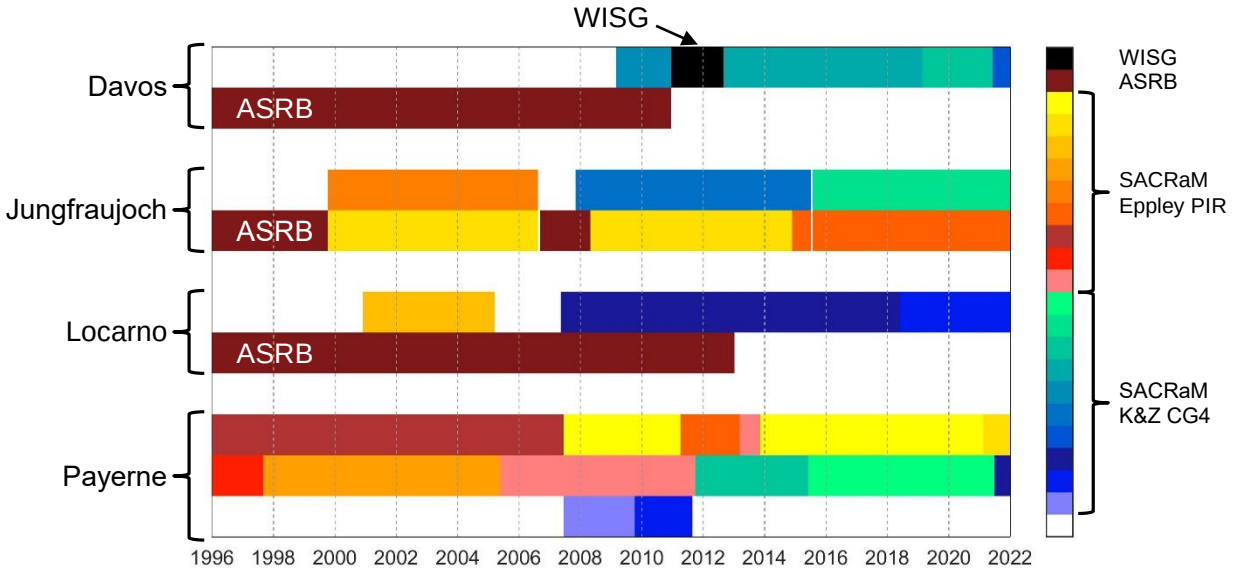
- Increasing IR↓ should be the most direct consequence of increasing GHG concentration
  - Tool for studying climate change
- IR↓ radiation trends demonstrate increasing greenhouse effect in Switzerland
  - Clear-sky and all-sky IR↓ trends at 4 stations all positive and all but one significant (between about 1 and 5 Wm^{-2} per decade)

Are the time series homogenous?

Measurements from two networks put together:

- **Instrument changes**
  - Instrument exchanges
  - Instrument model changes
- **Calibration method changes**
- Trend differences when using different instruments

→ **Homogenization needed!**



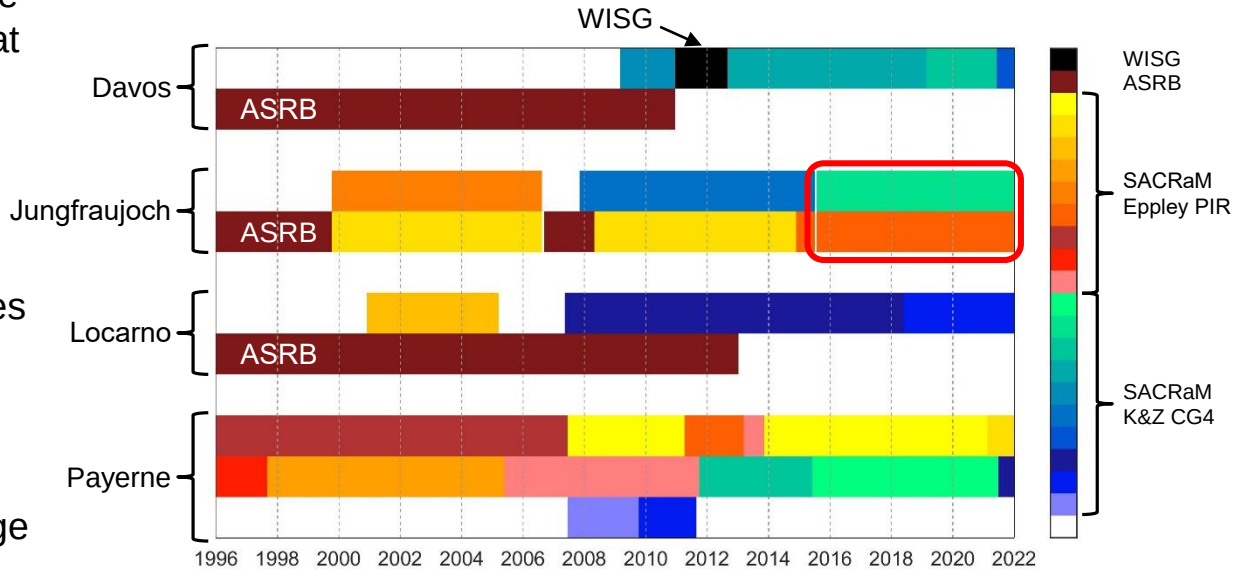
Are the time series homogenous?

Example of significant and variable differences between instruments at Jungfraujoch:

- K&Z CGR4 120470
- Eppley PIR 29587F3

Differences computed for two types of environmental conditions:

- High cloud coverage (low net signal)
- Clear-sky or low cloud coverage (stronger net signal)



Are the time series homogenous?

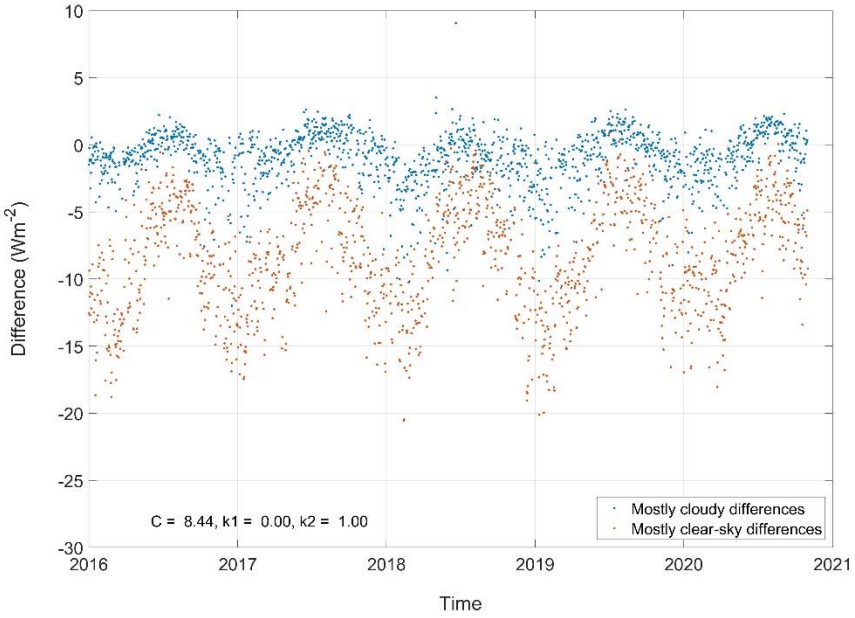
Example of significant and variable differences between instruments at Jungfraujoch:

- K&Z CGR4 120470 Original K&Z cal
- Eppley PIR 29587F3 Full PMOD/WRC cal

Differences computed for two types of environmental conditions:

- High cloud coverage (low net signal)
- Clear-sky or low cloud coverage (stronger net signal)

CGR4 – PIR daily averages of differences



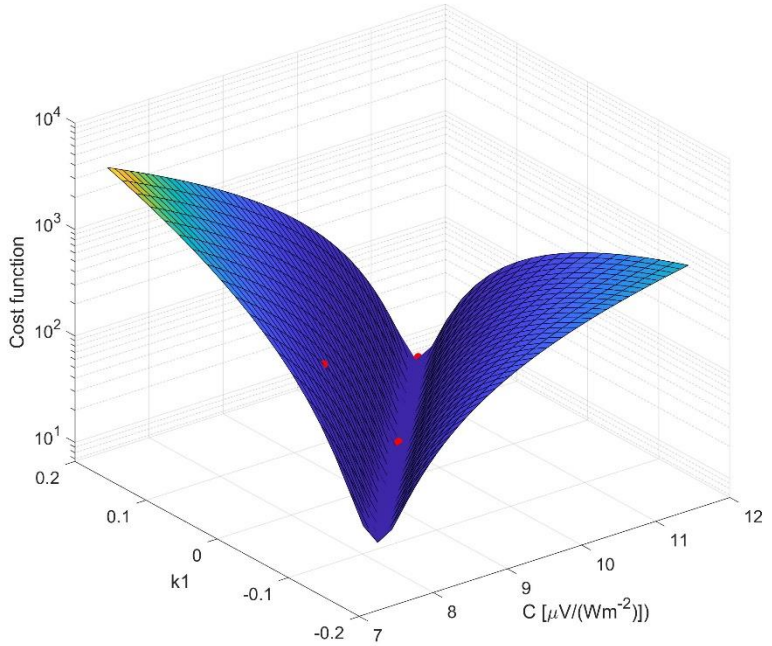
Homogenization trial

Adjusting C, k_1 and k_2 for K&Z CGR4 120470 by minimizing cost function:

$$K = \frac{1}{n}\sum_{i=0}^{n}\left(E_i - E_i^{ref}\right)^2$$

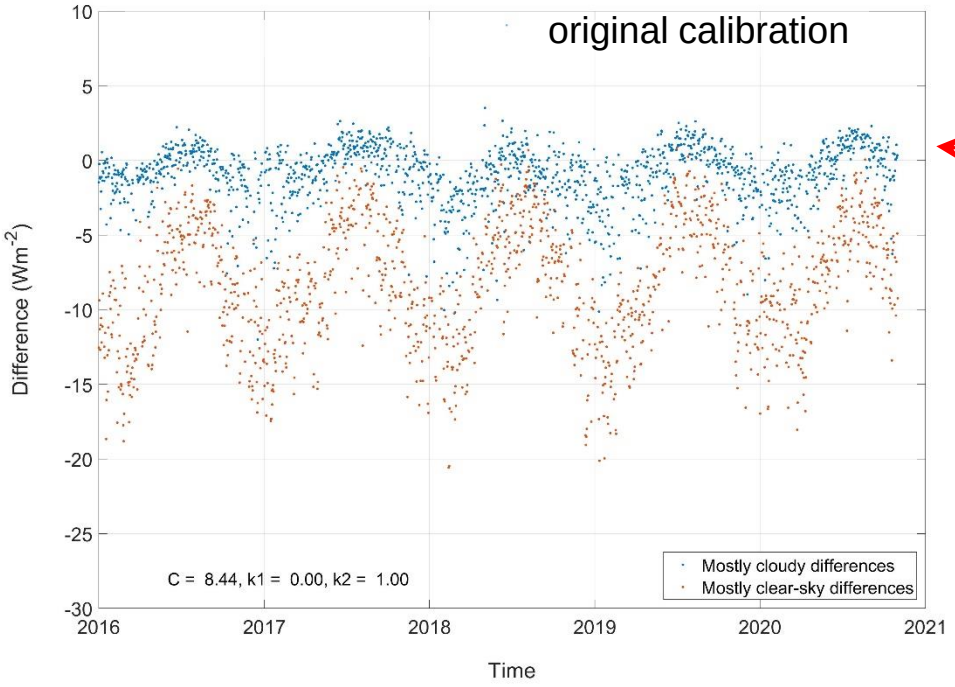
with:

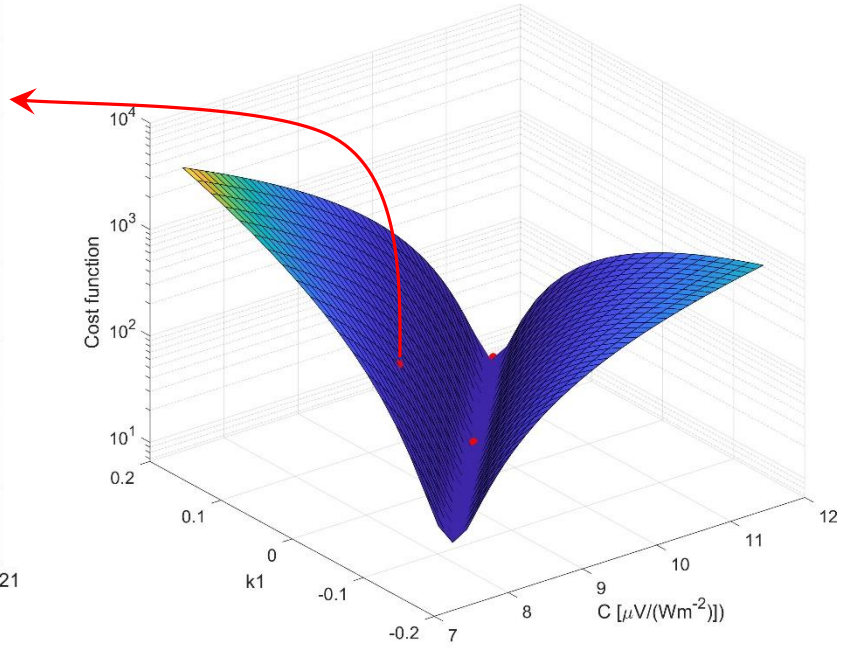
$$E_i = \underbrace{\frac{U_i}{C}\left(1 + k_1\sigma T_{iB}^3\right)}_{\mathrm{IR}_{\downarrow}^{\mathrm{atm}} - \mathrm{IR}_{\uparrow}^{\mathrm{inst}}} + \underbrace{k_2\sigma T_{iB}^4}_{\mathrm{IR}_{\uparrow}^{\mathrm{inst}}}$$



Homogenization trial

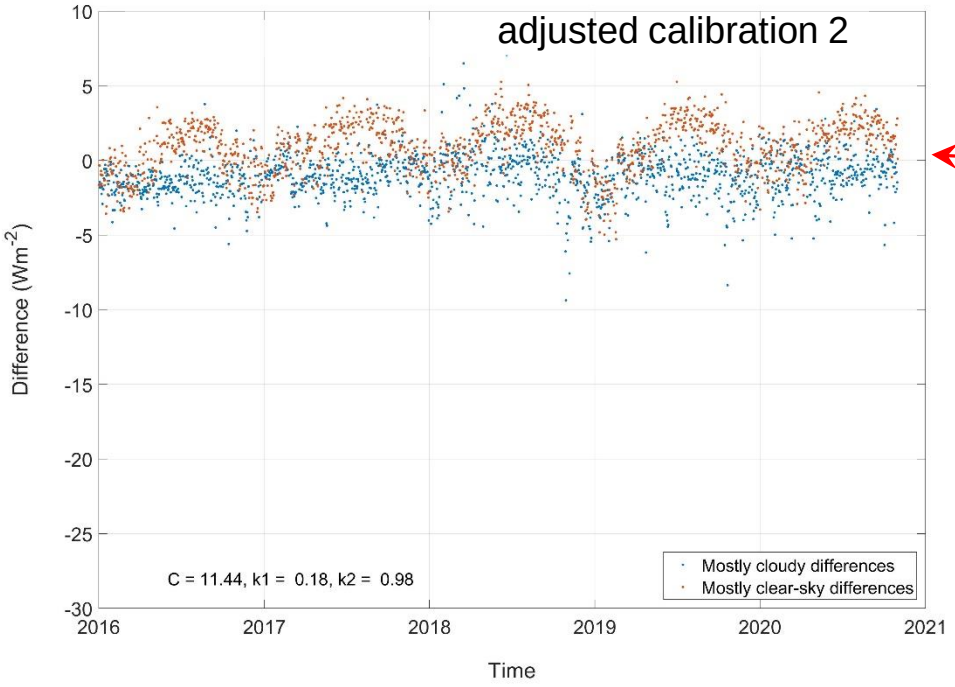
CGR4 – PIR daily averages of differences

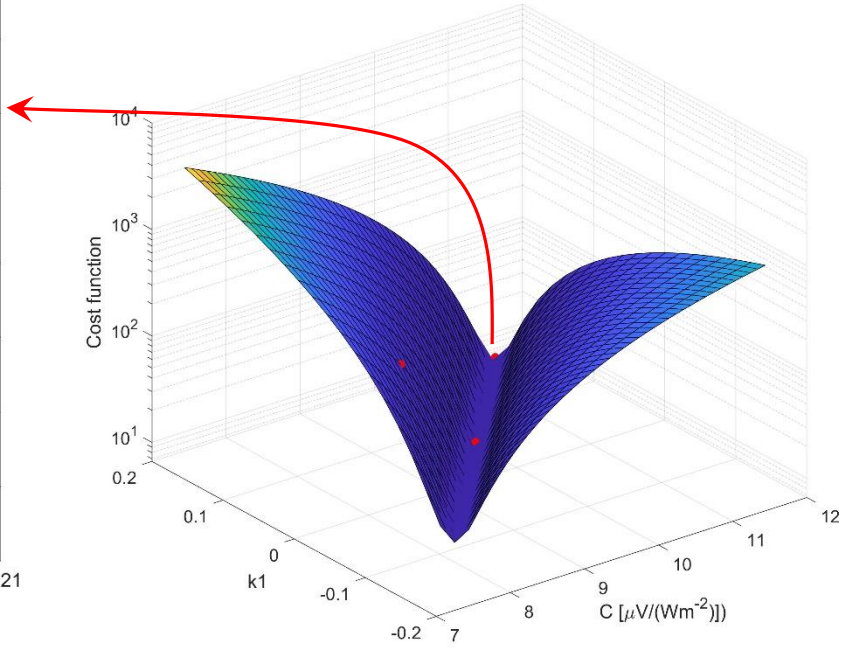




Homogenization trial

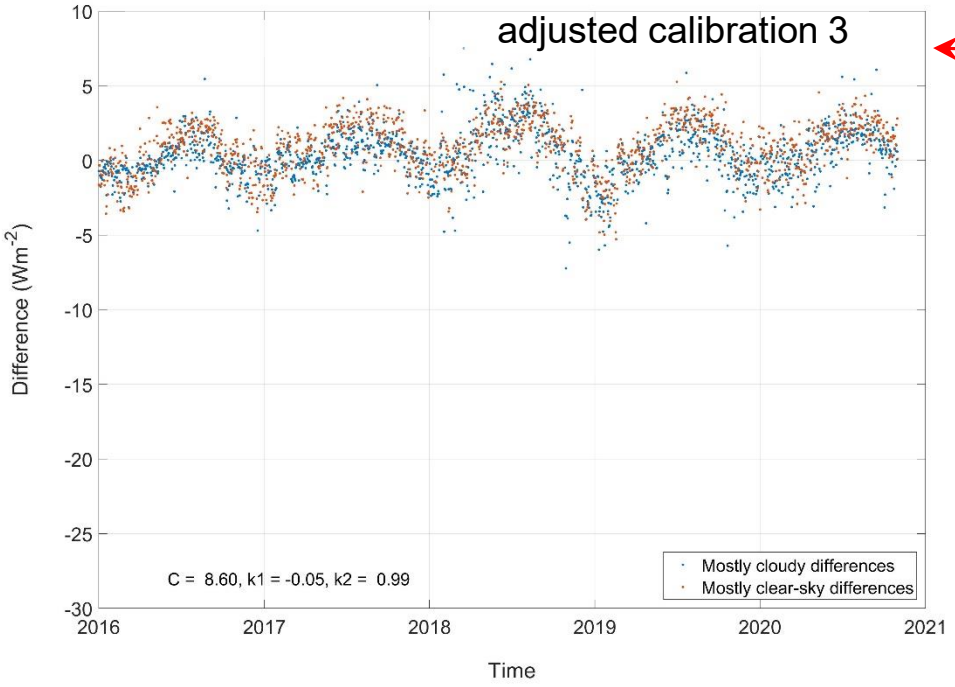
CGR4 – PIR daily averages of differences

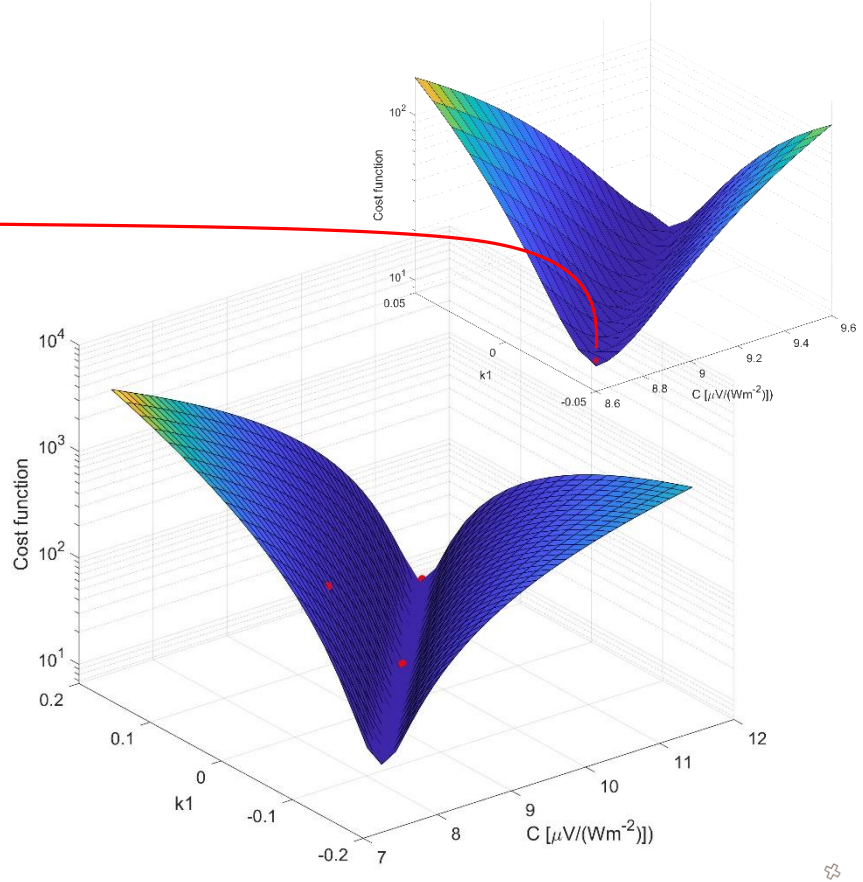




Homogenization trial

CGR4 – PIR daily averages of differences





Summary

- Changes in calibration method (more refined methods) introduced inhomogeneity in the IR↓ time series
- Homogenization of time series required for confidence in trends
  - Homogenization of IR↓ time series complex due to nature of instrument
  - IR↓ time series homogenization also important in framework of radiation reference update

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