See:NASA "Blue Marble"

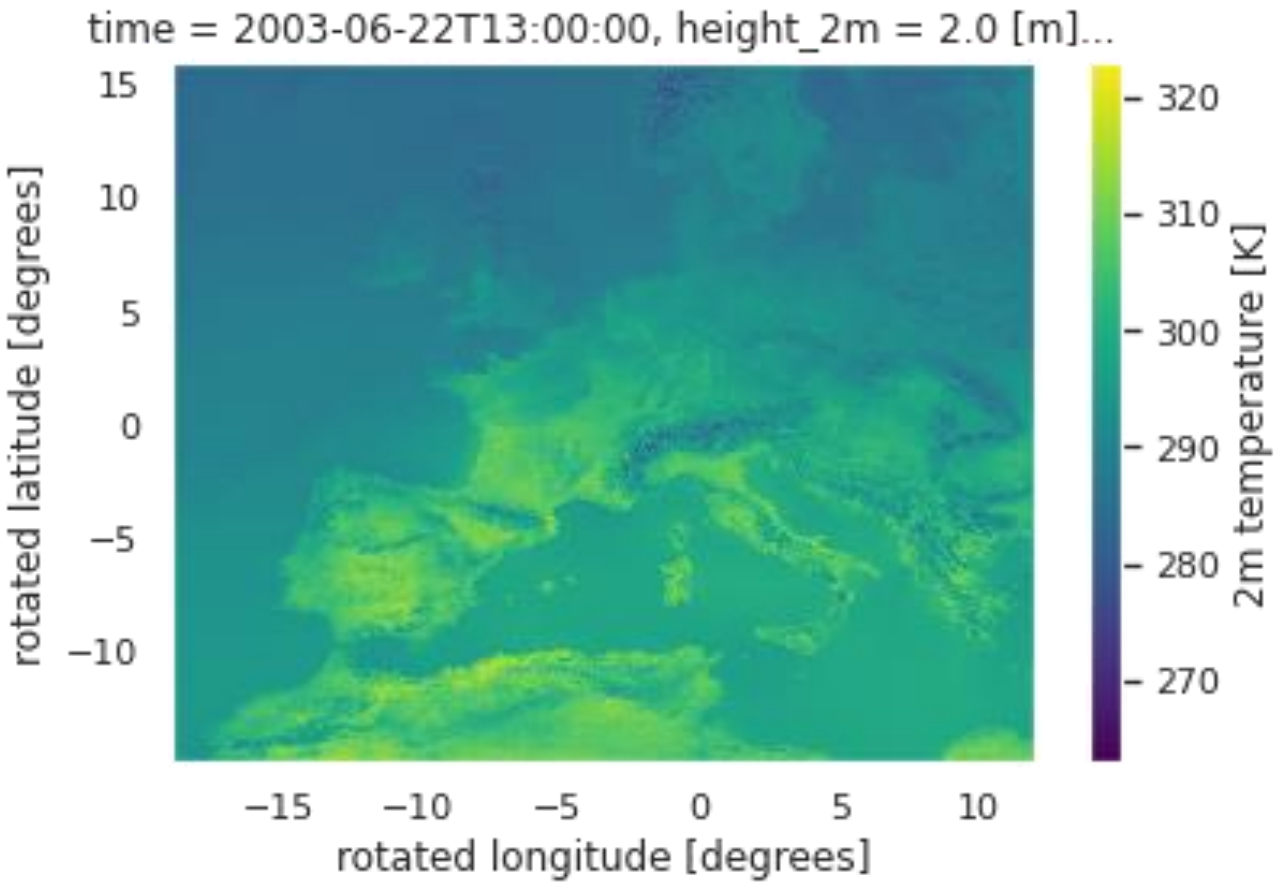
Downscaling of climate models

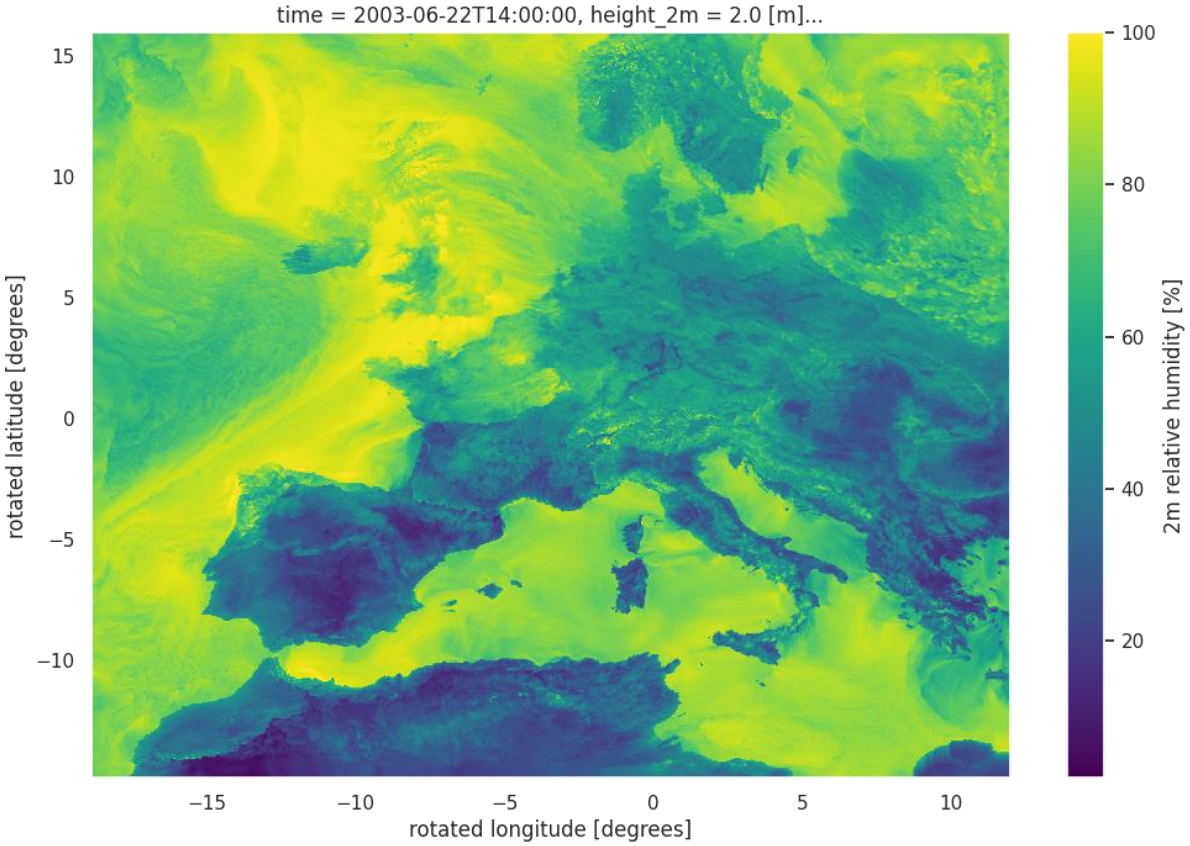
Léo Micollet

ENSTA IP PARIS

UNIL | Université de Lausanne

Climate models, weather and climate predictions





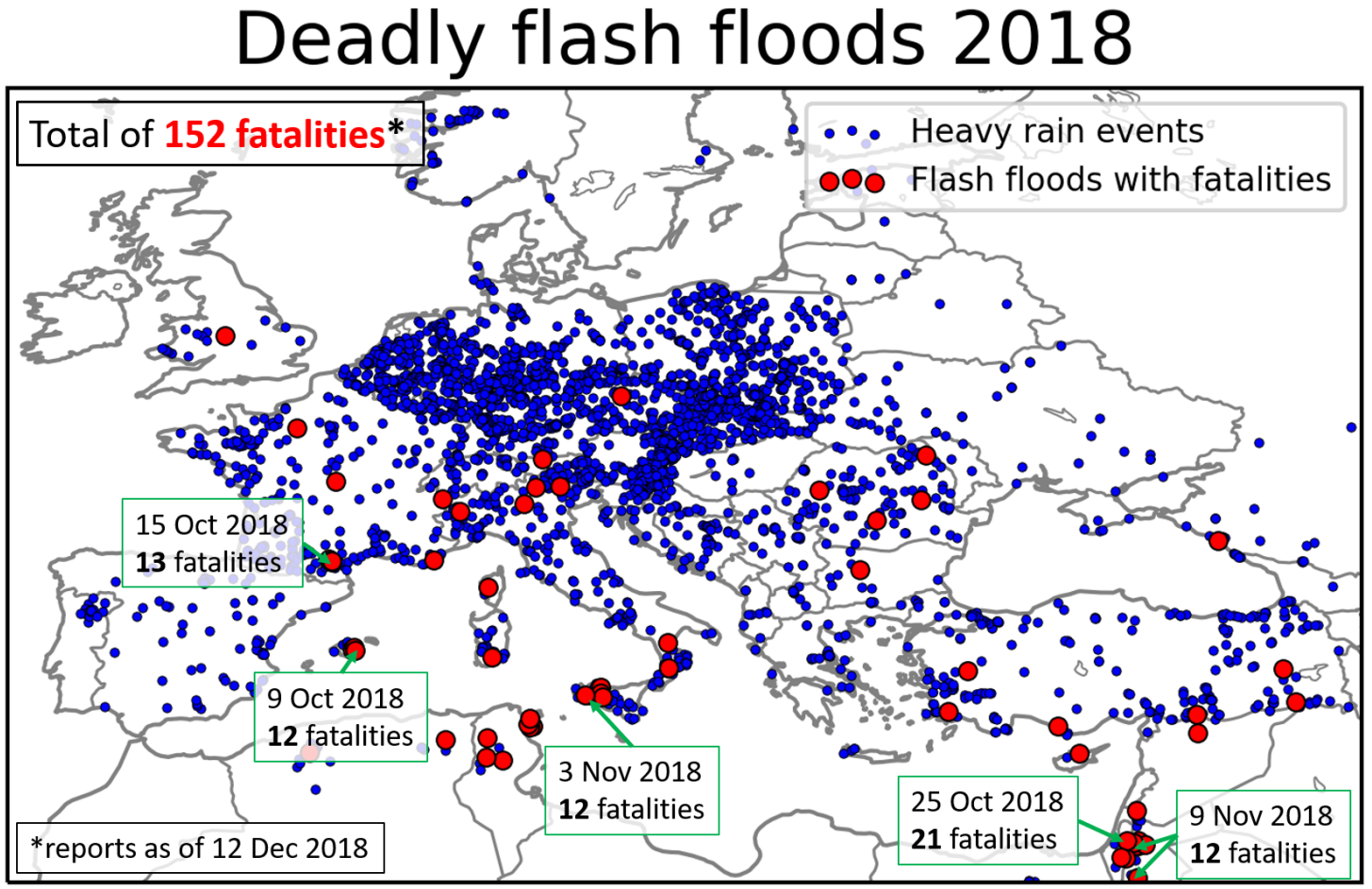
Future climate predictions

Issues:

- Historical values available
- Too coarse resolution
- No long enough predictions

Objectives:

- Fine resolution predictions over large areas
- Foresee small scale events on bigger time scales

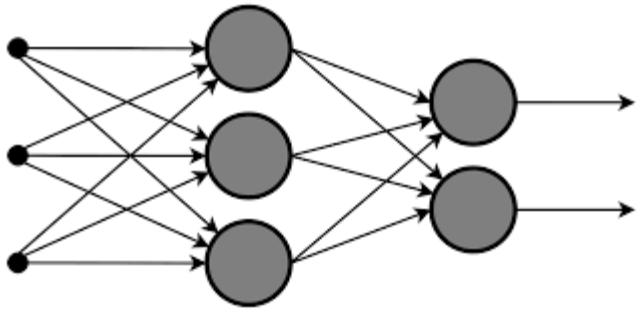


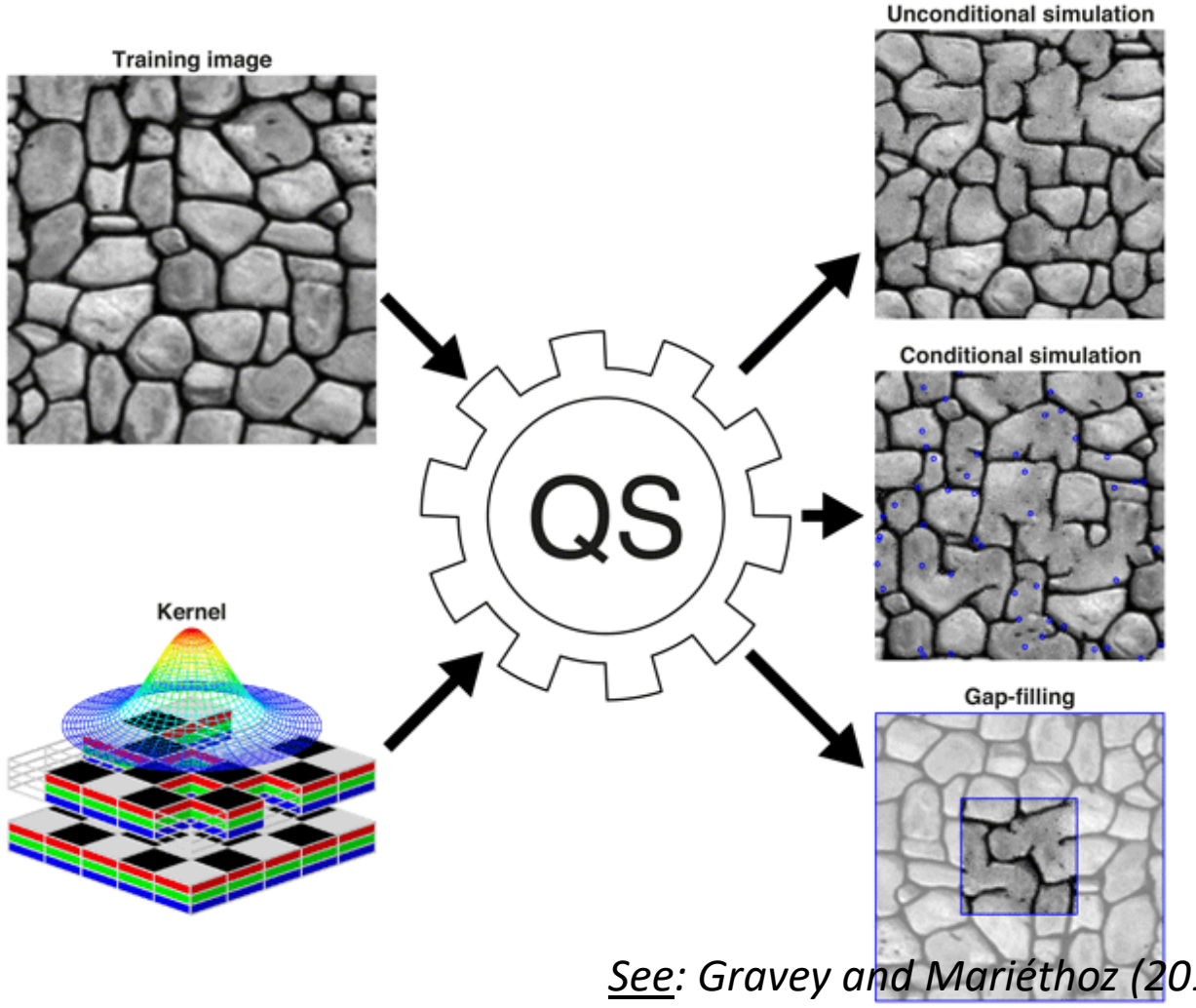
See: EESL "Blue Marble"

Downscaling in a changing climate

Methods:

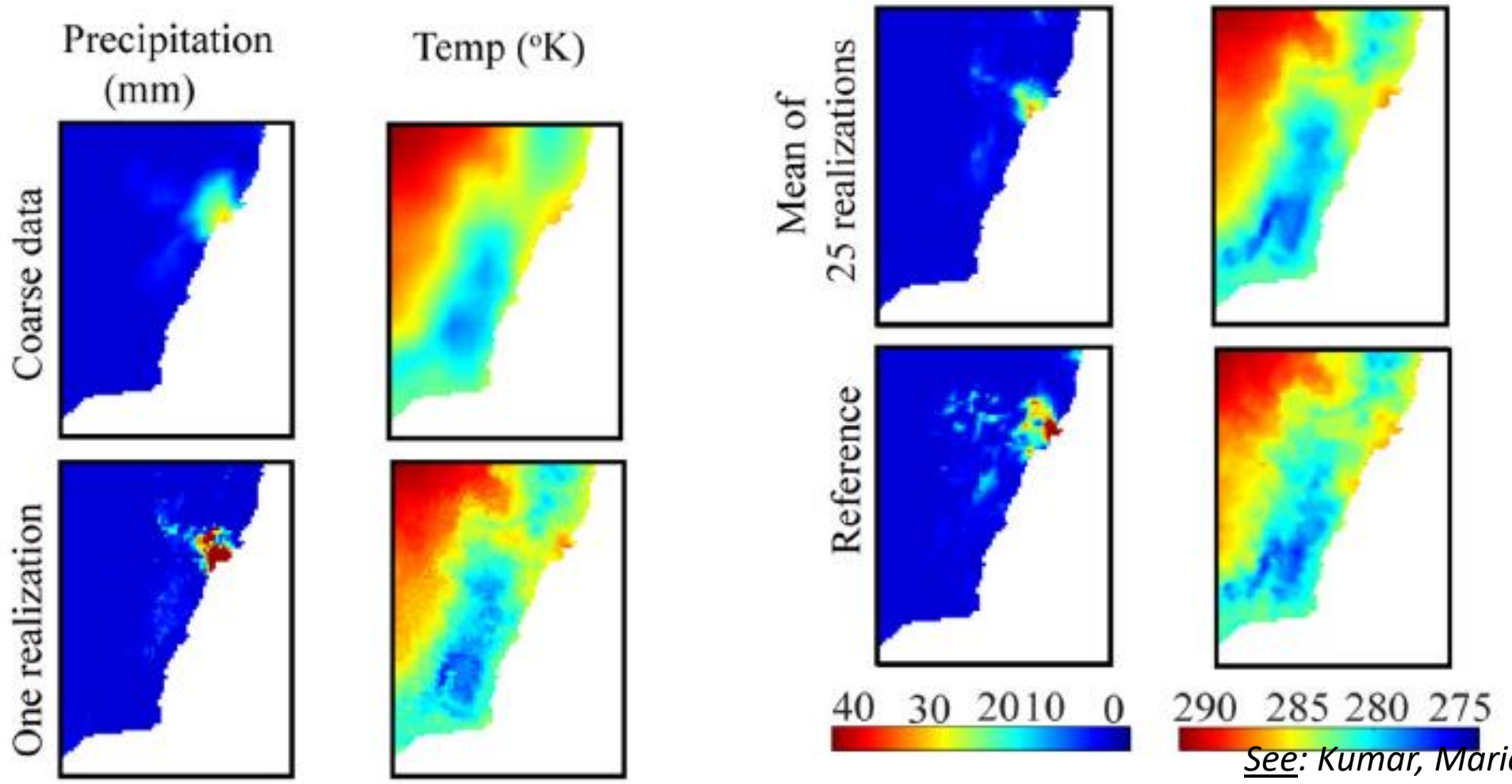
- Multiple point Geostatistics (QS)
- Machine learning (SRGAN, CNN)





See: Gravey and Mariéthoz (2019)

Downscaling in a changing climate: QuickSampling



See: Kumar, Mariéthoz et al. (2015)

Downscaling in a changing climate: SRGAN and CNN

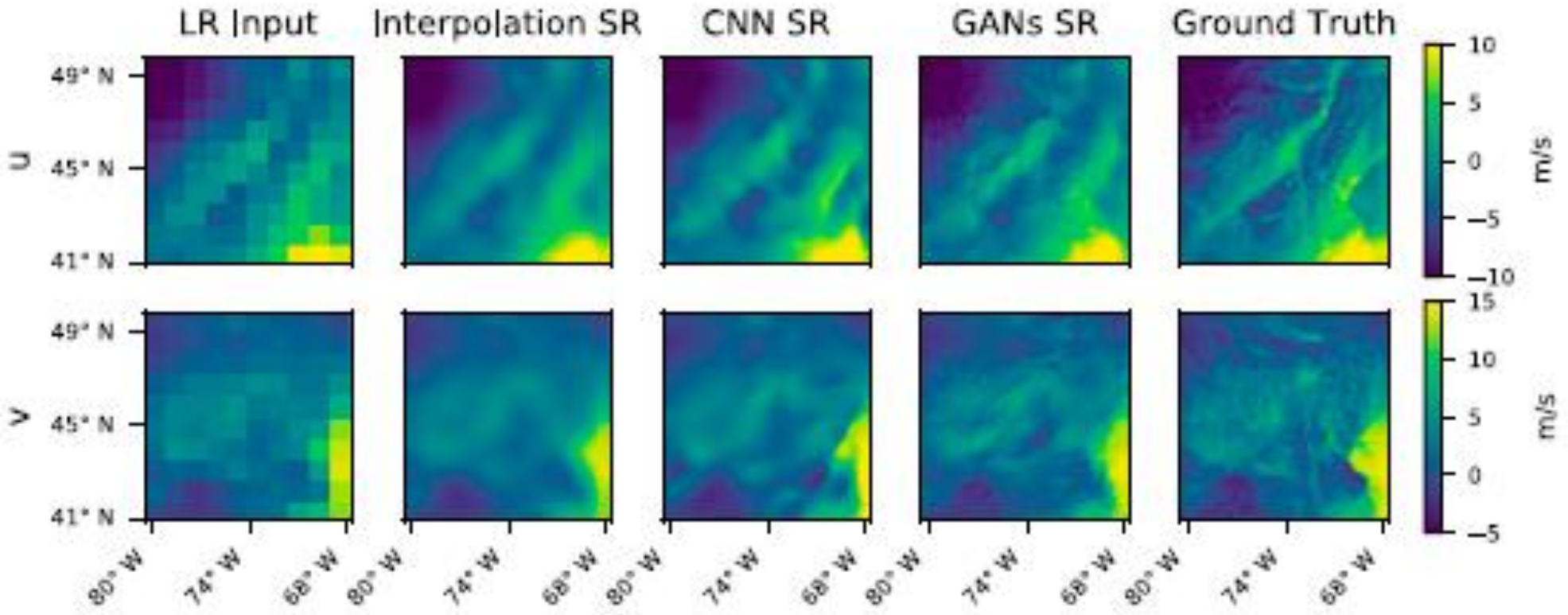


Fig. 3. Comparison of various SR methods on WIND Toolkit data fields.

See: Stengels, Glaws et al. (2020)

Downscaling in a changing climate: CNN

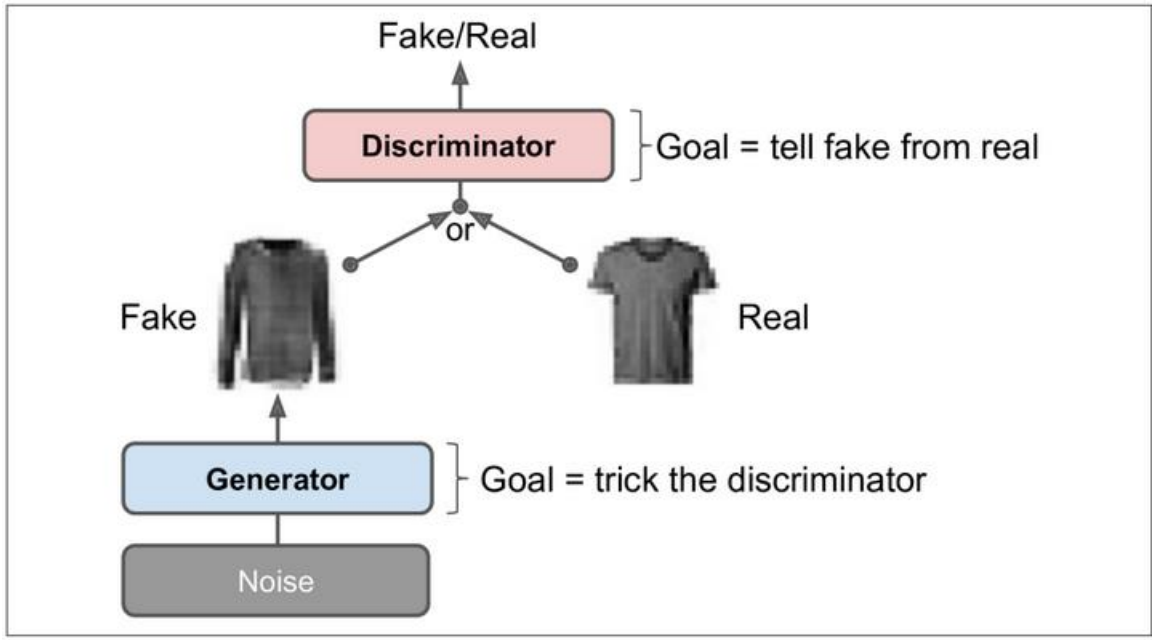
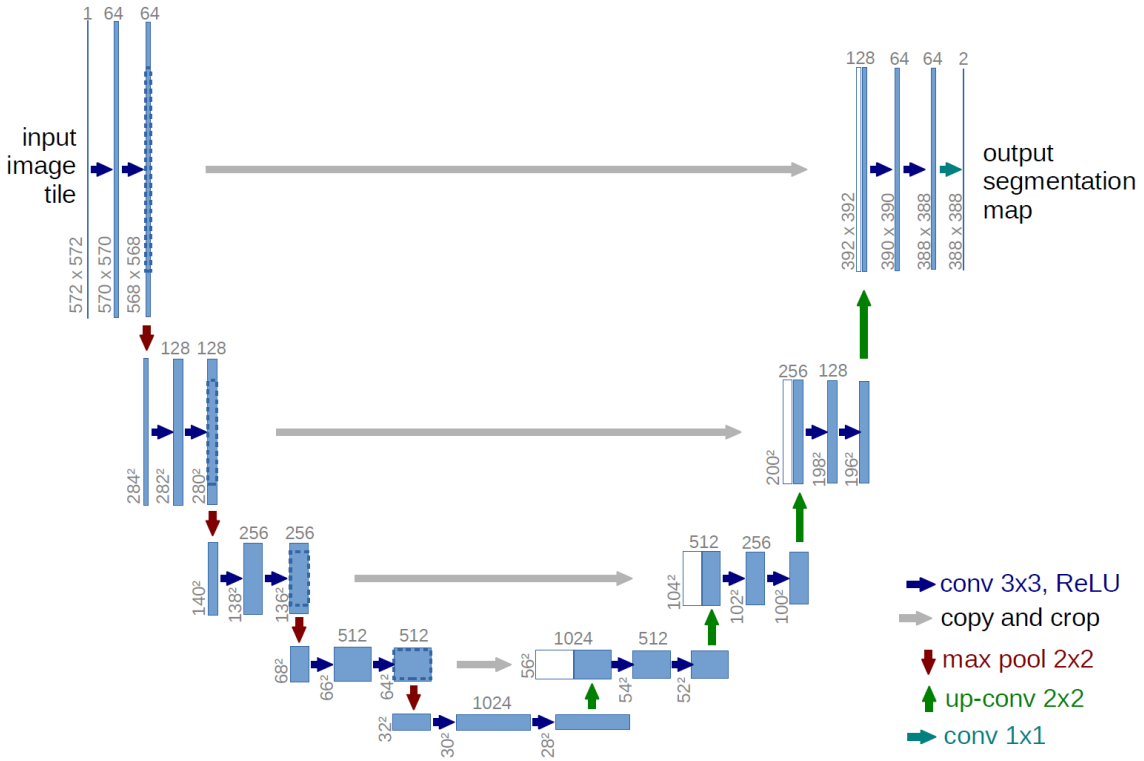


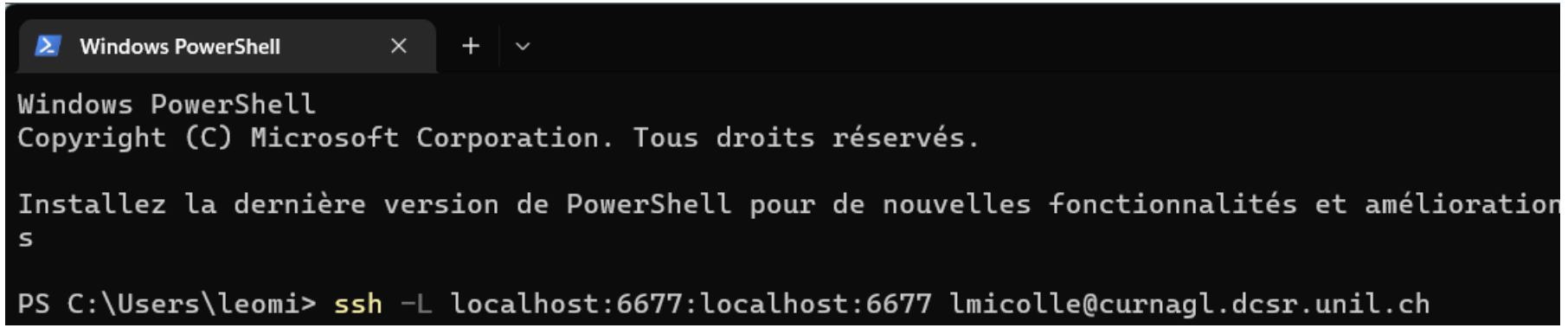
Figure 17-15. A generative adversarial network

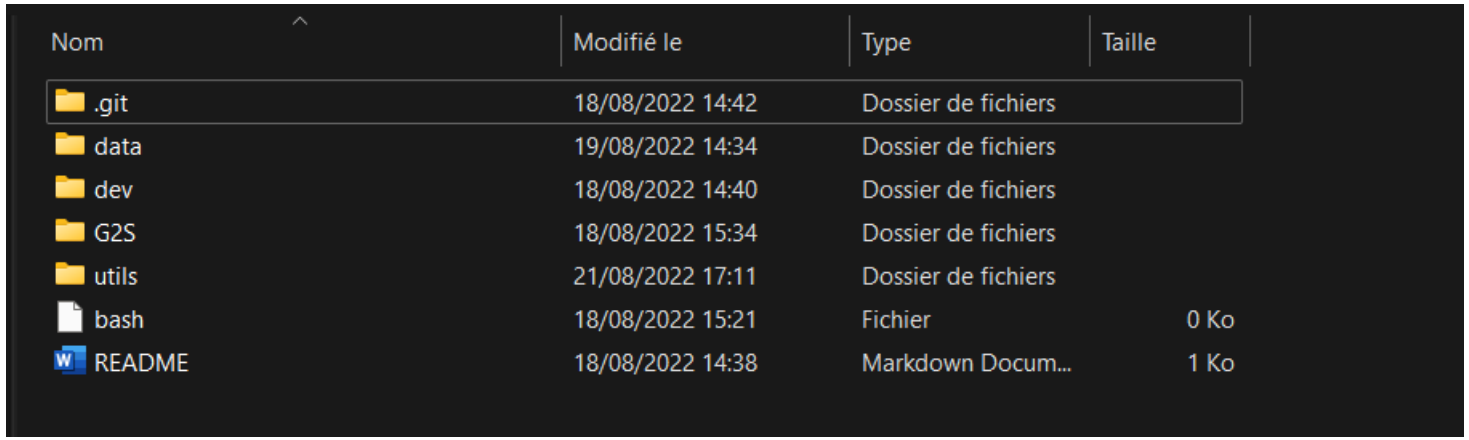
See: Aurelien Géron, Hands on machine learning (2017)



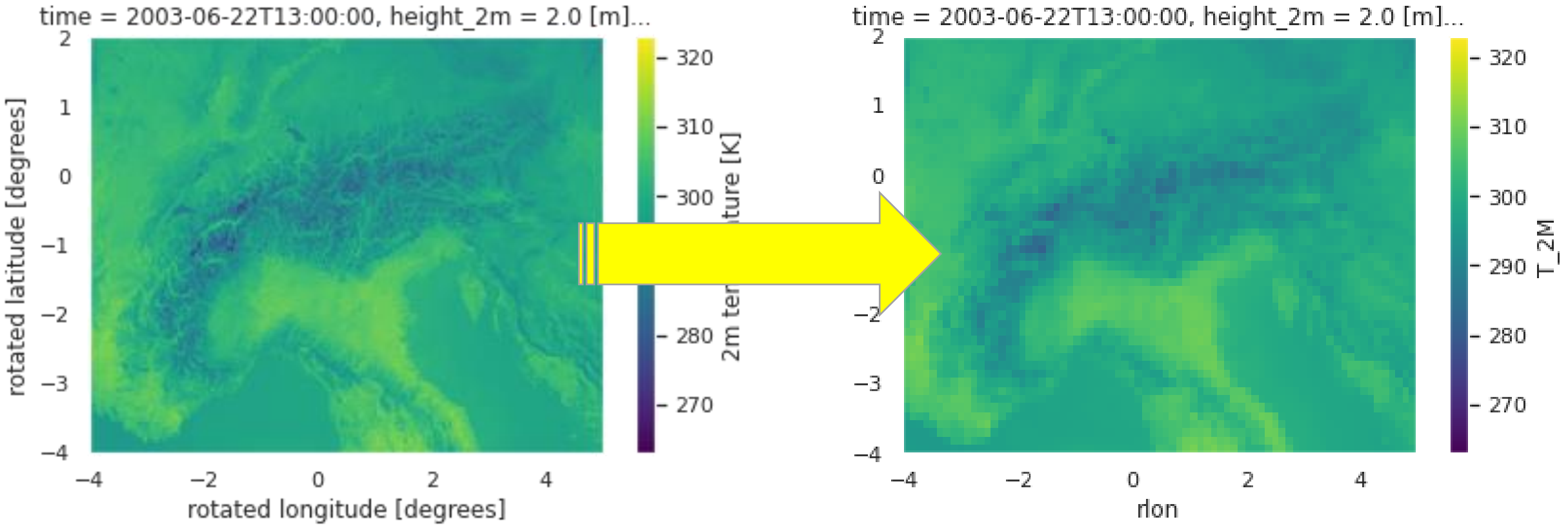
See: Ronneberger, Fischer, Brox (2015)

Working with remote data





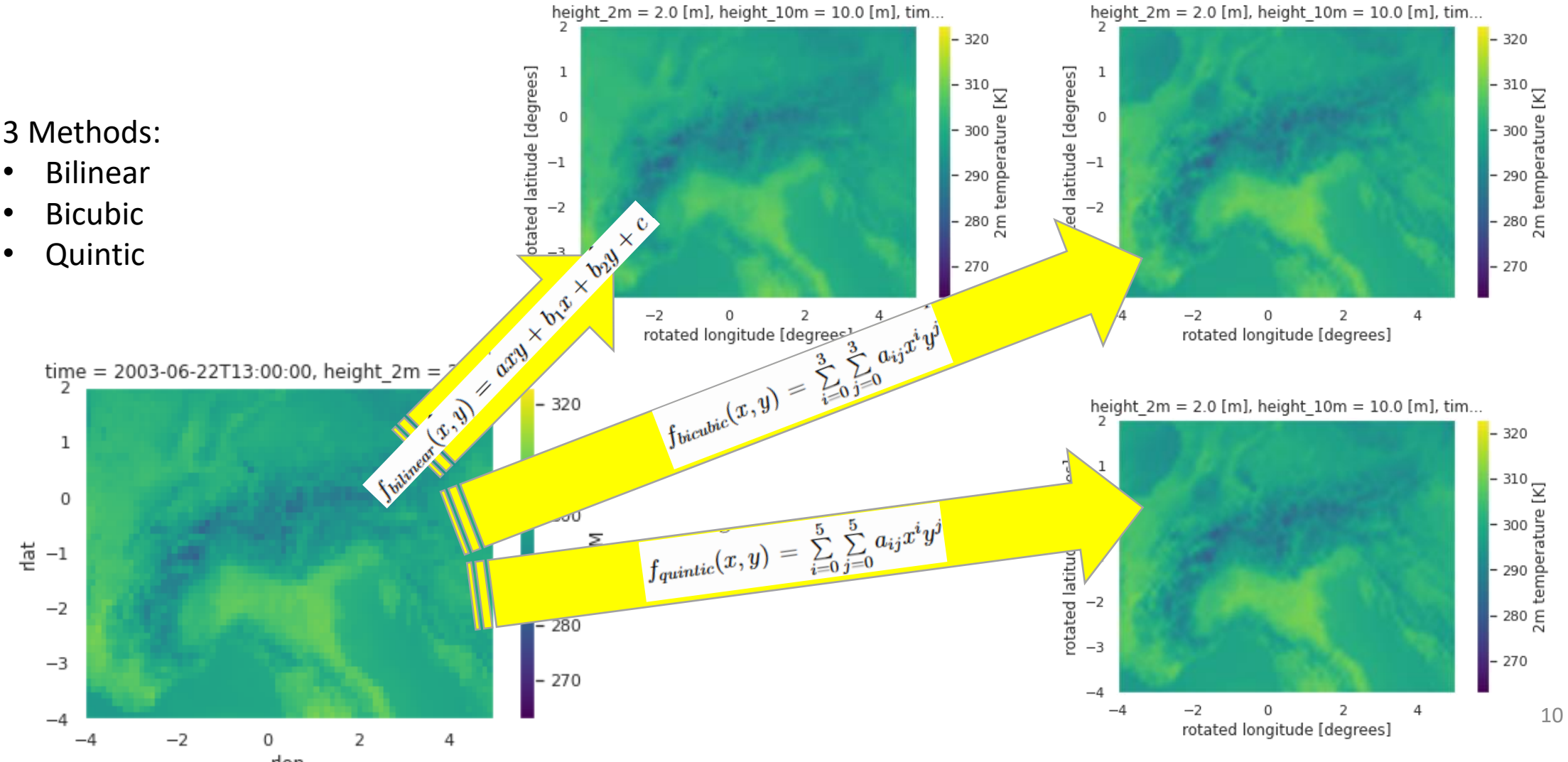
Upscaling


time = 2003-06-22T13:00:00, height_2m = 2.0 [m]...
rotated latitude [degrees]
rotated longitude [degrees]
2m temperature [K]
time = 2003-06-22T13:00:00, height_2m = 2.0 [m]...
rlon
T_2M

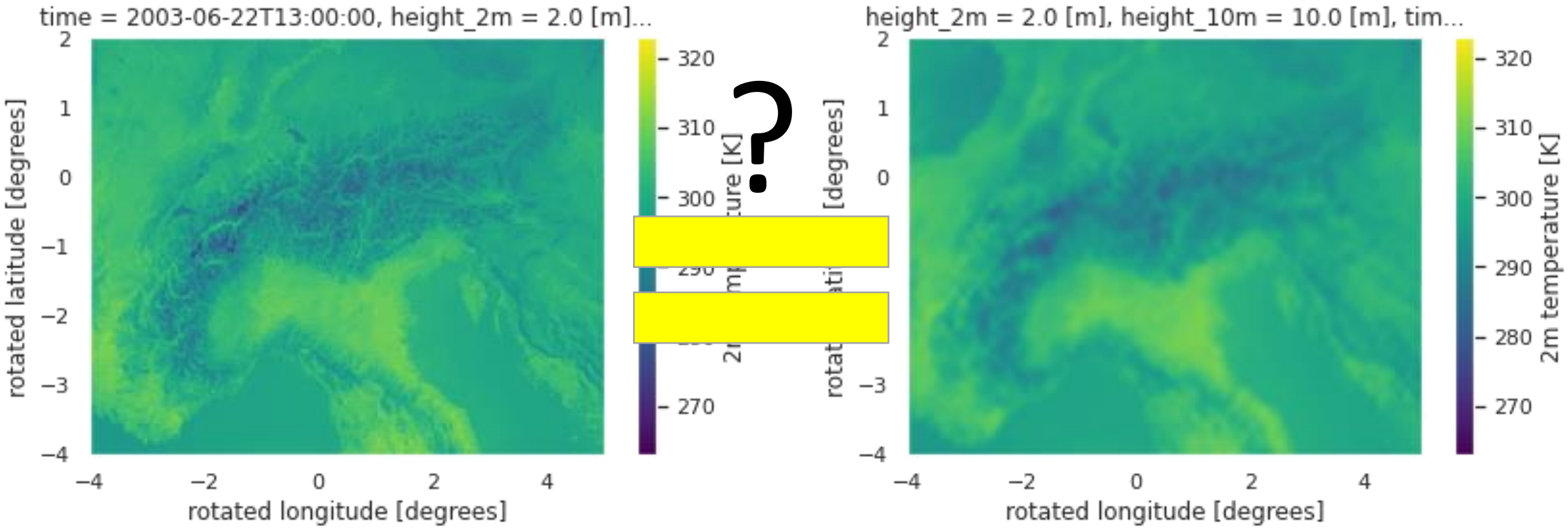
Baselines implementation

3 Methods:

- Bilinear
- Bicubic
- Quintic



Metrics implementation



Metrics implementation: Pixel-wise metrics

$$RMSE = \sqrt{\frac{\sum_{1}^{n}(x_{i\ original} - x_{i\ downscaled})^2}{n}}$$

$$MAE = \frac{1}{n}\sum_{1}^{n}|x_{i\ original} - x_{i\ downscaled}|$$

Metrics implementation: SSIM

$$l(x,y) = \frac{2\mu_x\mu_y + C_1}{\mu_x^2 + \mu_y^2 + C_1}; \quad c(x,y) = \frac{2\sigma_x\sigma_y + C_2}{\sigma_x^2 + \sigma_y^2 + C_2}; \quad s(x,y) = \frac{\sigma_{xy} + C_3}{\sigma_x\sigma_y + C_3}$$

$$SSIM(x,y) = f(l(x,y), c(x,y), s(x,y)) = \frac{(2\mu_x\mu_y + C_1)(2\sigma_{xy} + C_2)}{\left(\mu_x^2 + \mu_y^2 + C_1\right)\left(\sigma_x^2 + \sigma_y^2 + C_2\right)}$$

Metrics implementation: Pdf metrics

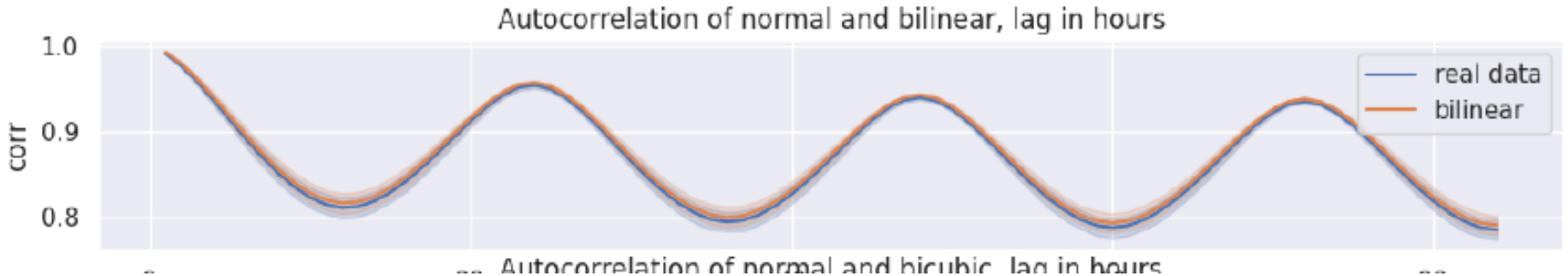
- Hellinger distance :

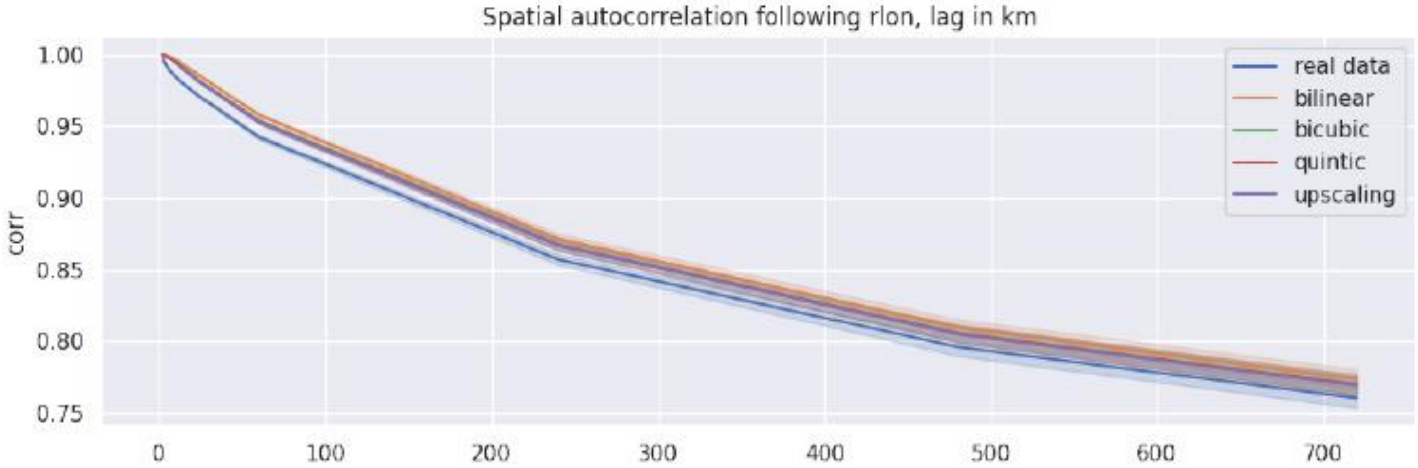
$$H^2(P,Q) = \frac{1}{\sqrt{2}} \cdot \|\sqrt{P} - \sqrt{Q}\|_2$$

- Perkins skill score:

$$P(f,g) = \int \min(f(x), g(x))dx$$

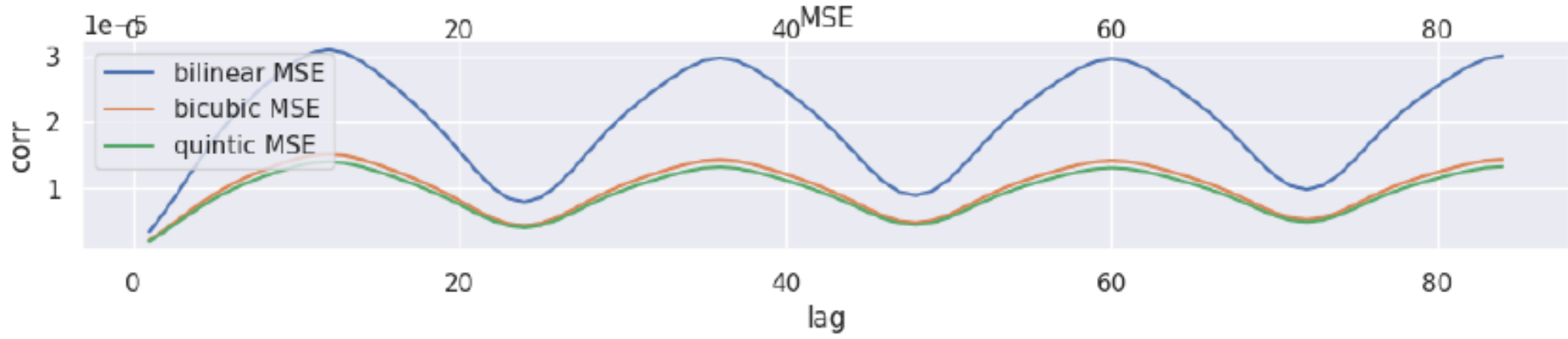
Metrics implementation: Temporal and spatial autocorrelation



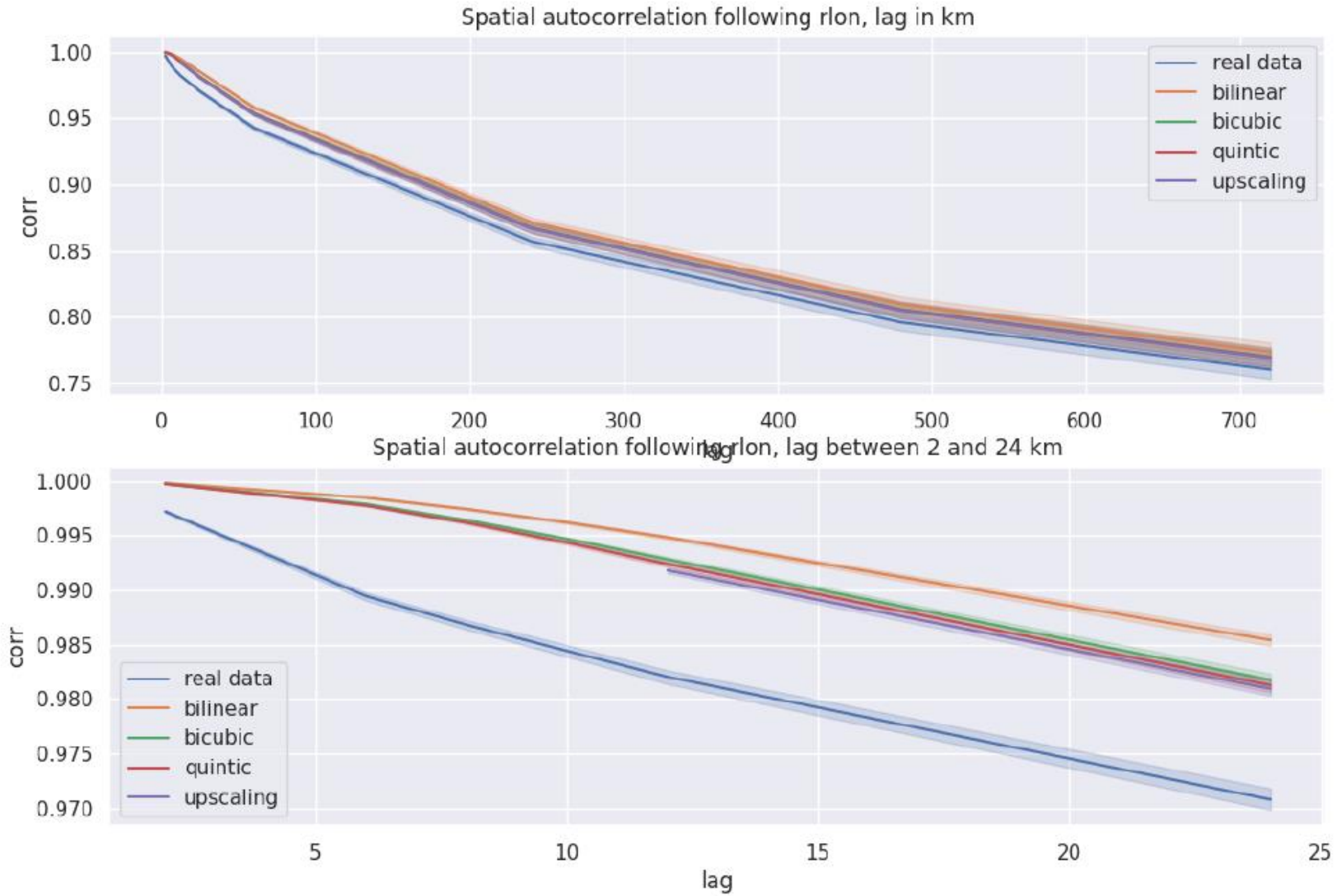


Baselines results: Temperature

method	RMSE	MAE	SSIM	Hellinger	Perkins
bilinear	0.756	0.378	0.5444	0.028	0.976
bicubic	0.76	0.378	0.5541	0.024	0.979
quintic	0.764	0.38	0.550	0.023	0.98

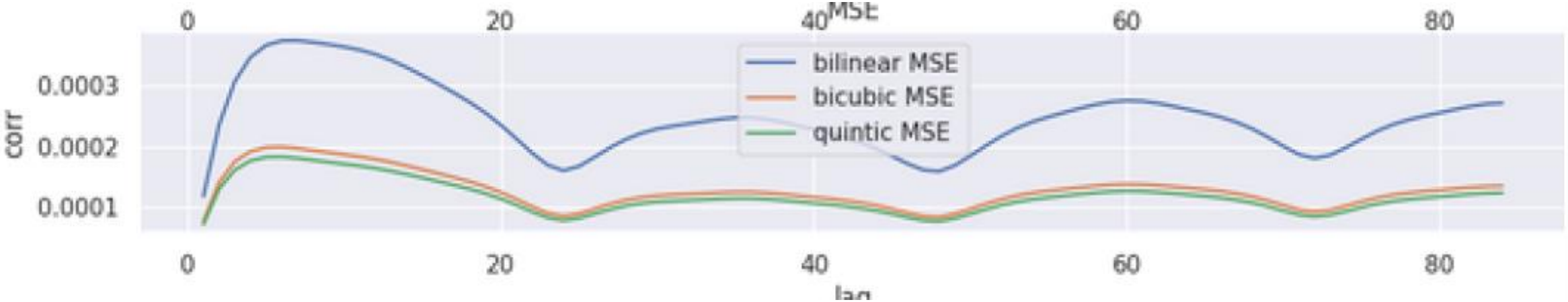


Baselines results: Temperature

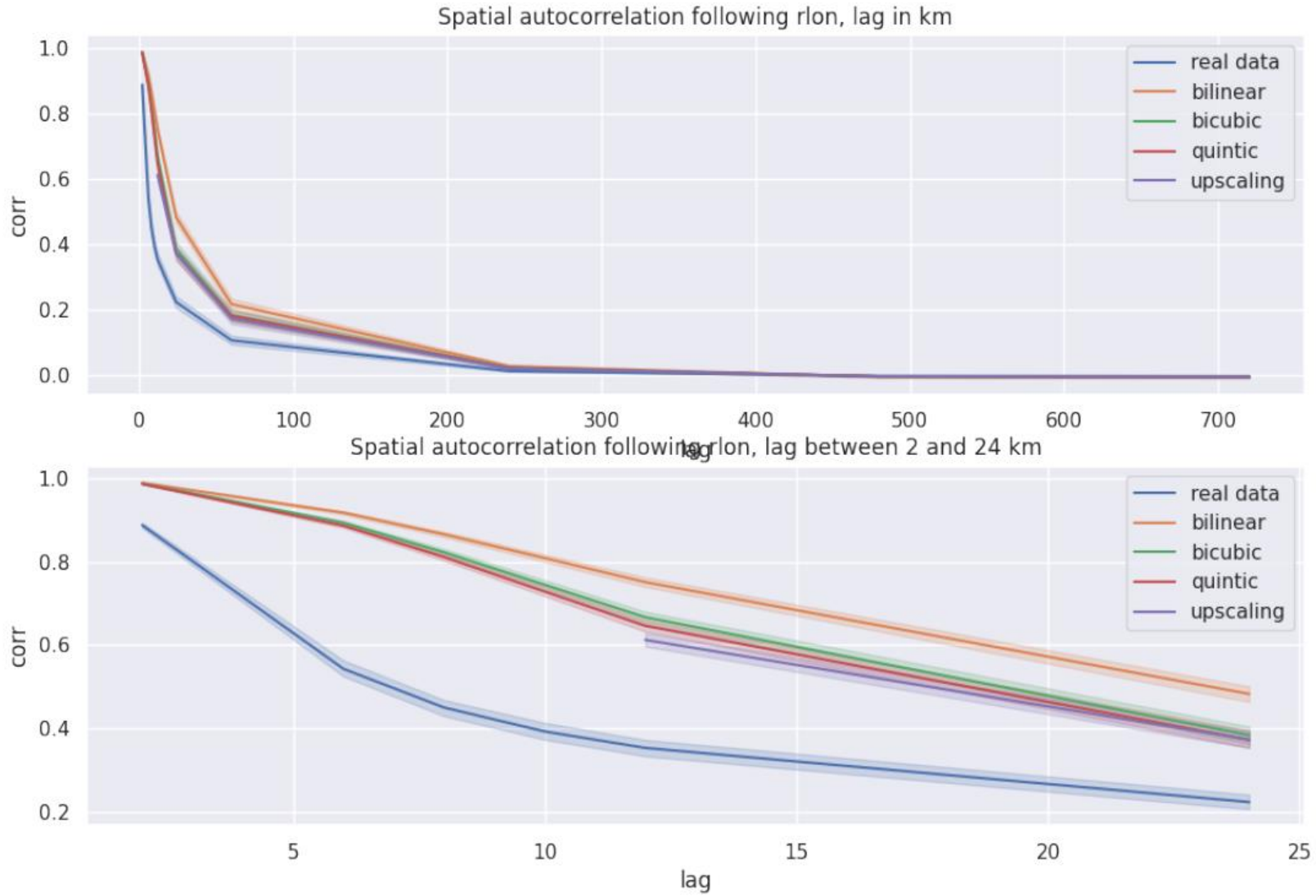


Baselines results: Relative humidity

method	RMSE	MAE	SSIM	Hellinger	Perkins
bilinear	3.46	1.97	0.380925	0.034	0.973364
bicubic	3.48	1.97	0.401112	0.028	0.977290
quintic	3.5	1.98	0.398616	0.028	0.977597

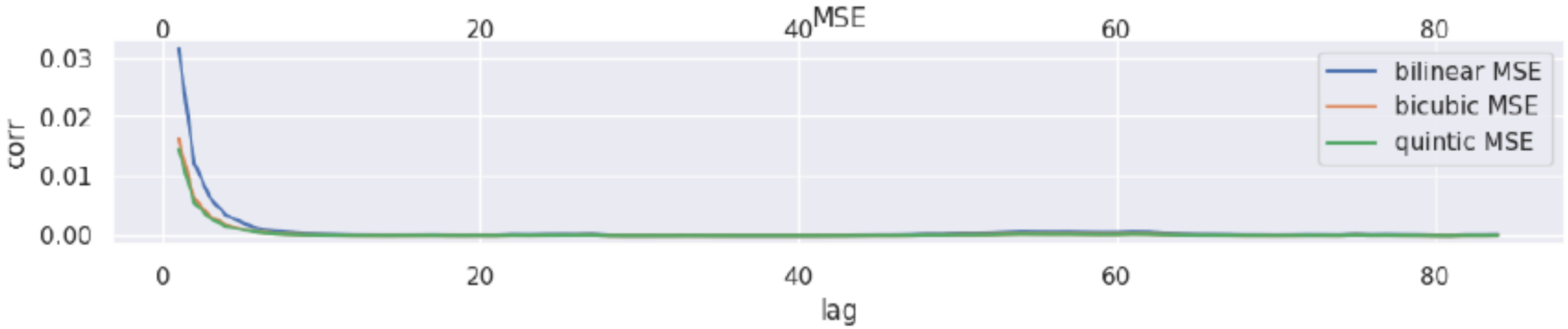


Baselines results: Relative humidity

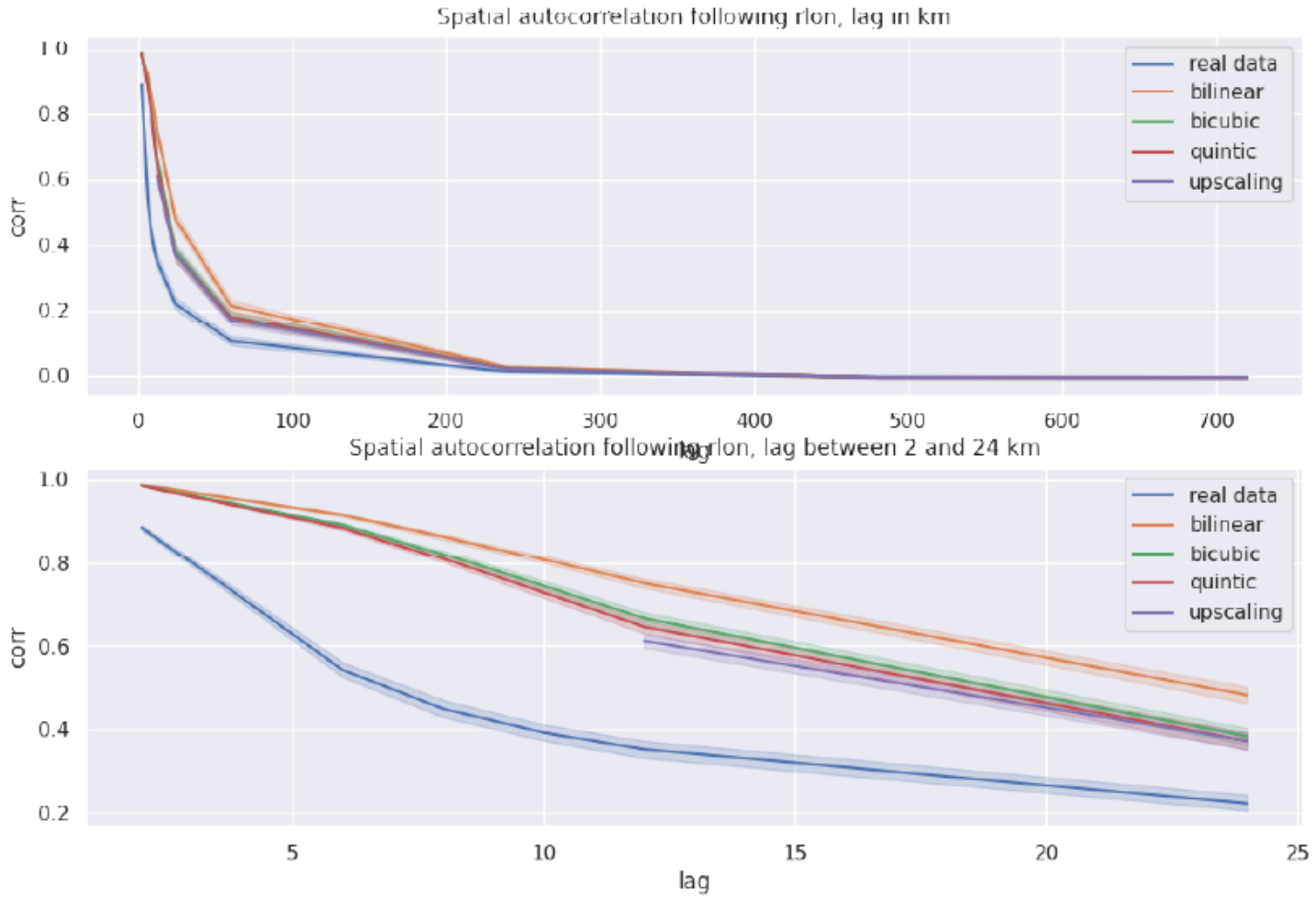


Baselines results: Total precipitations

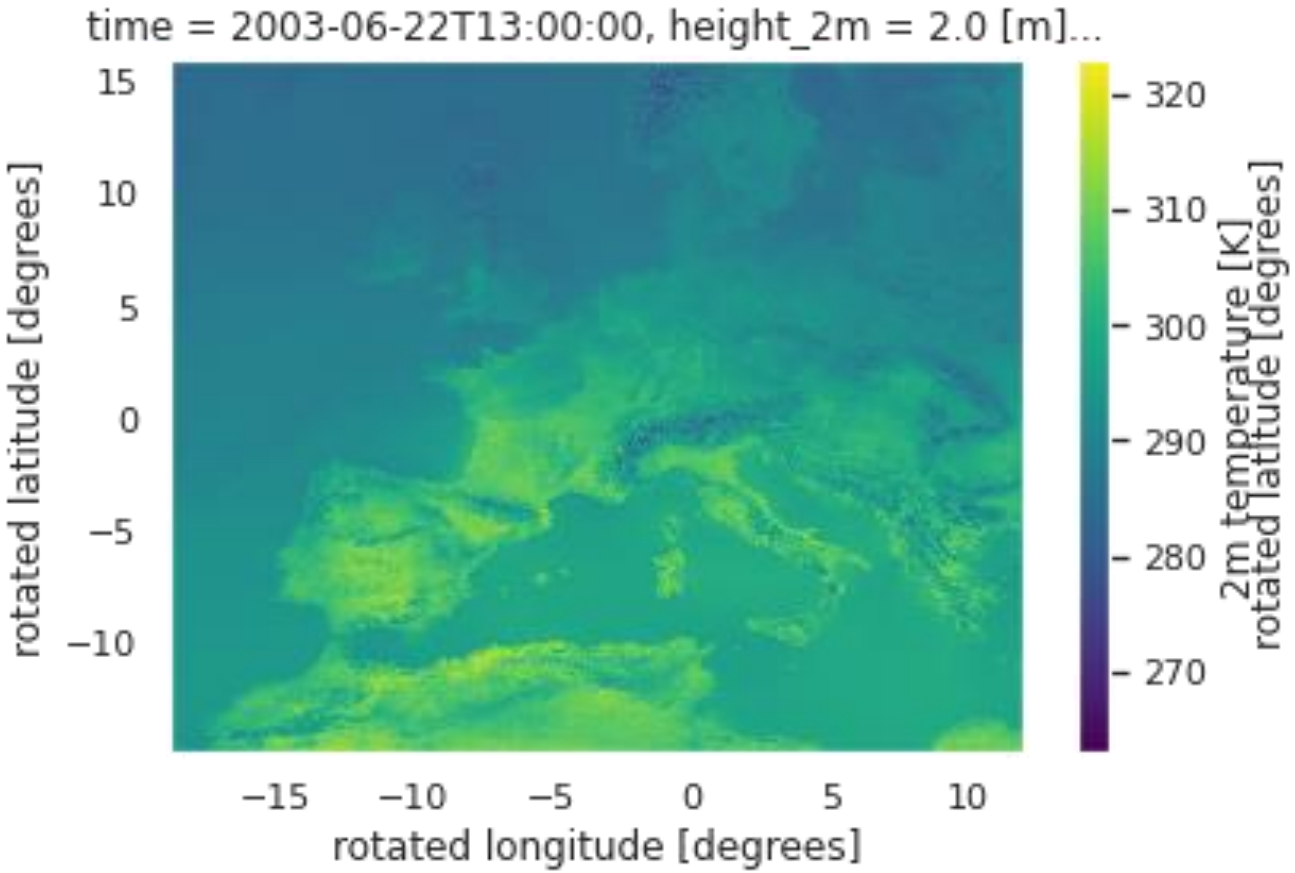
method	RMSE	MAE	SSIM	Hellinger	Perkins
bilinear	0.0002	0.000013	0.999974	0.04	0.514047
bicubic	0.0002	0.000014	0.999973	0.094	0.488452
quintic	0.0002	0.000015	0.999973	0.105	0.483243

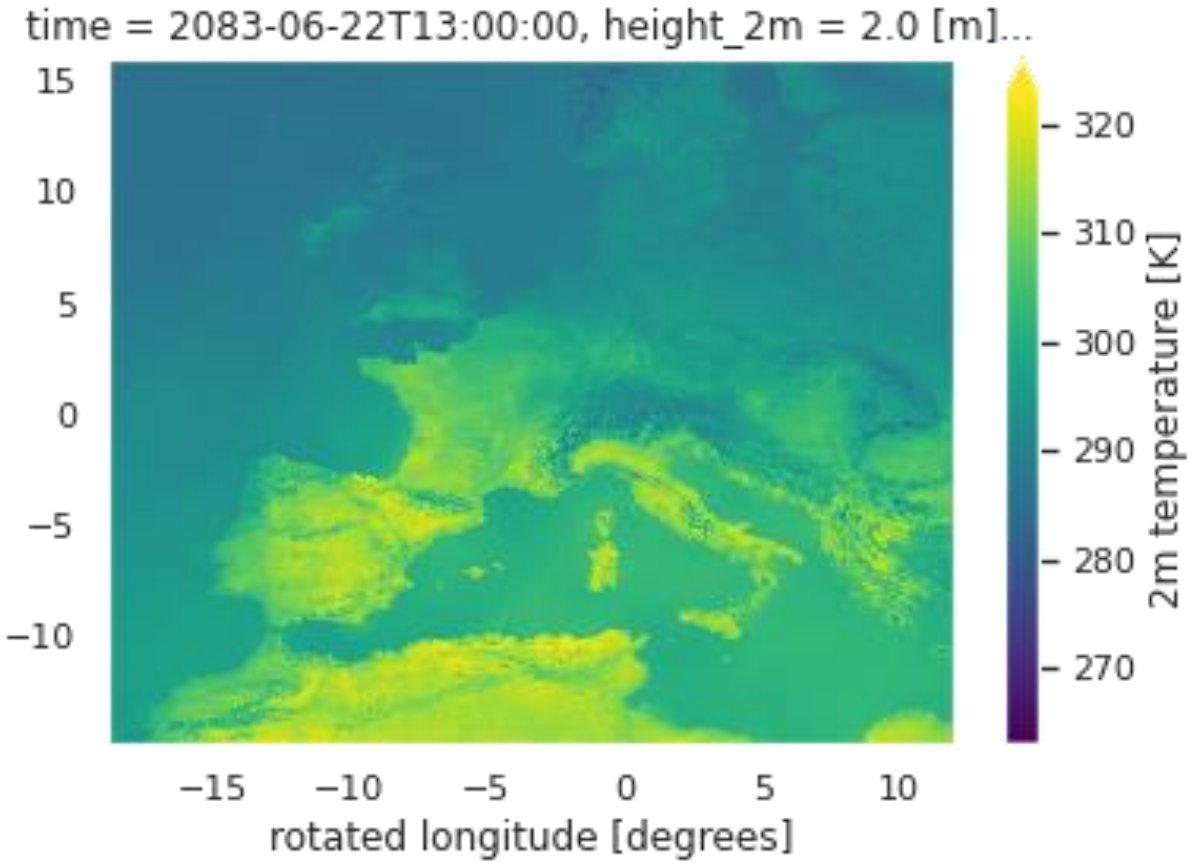


Baselines results: Total precipitations

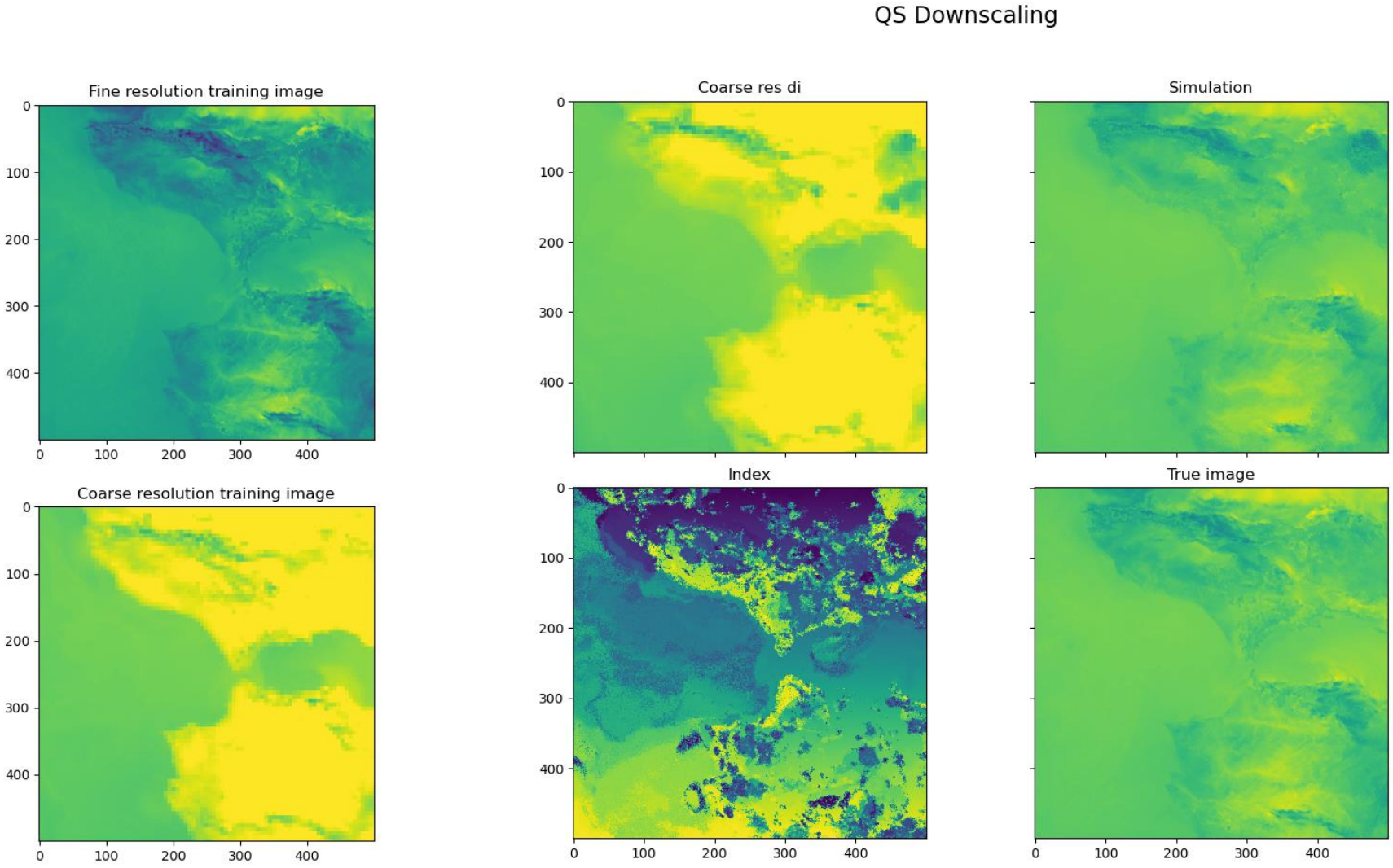


Baselines results: Future climate





QuickSampling results



Conclusion and future of this project