AN OPEN-SOURCE PYTHON PACKAGE FOR COMPUTING THE EFFECTIVE RESOLUTION OF REGIONAL CLIMATE MODELS: DEVELOPMENT, VALIDATION, AND IMPLICATIONS FOR THE CLIMATE MODELING COMMUNITY

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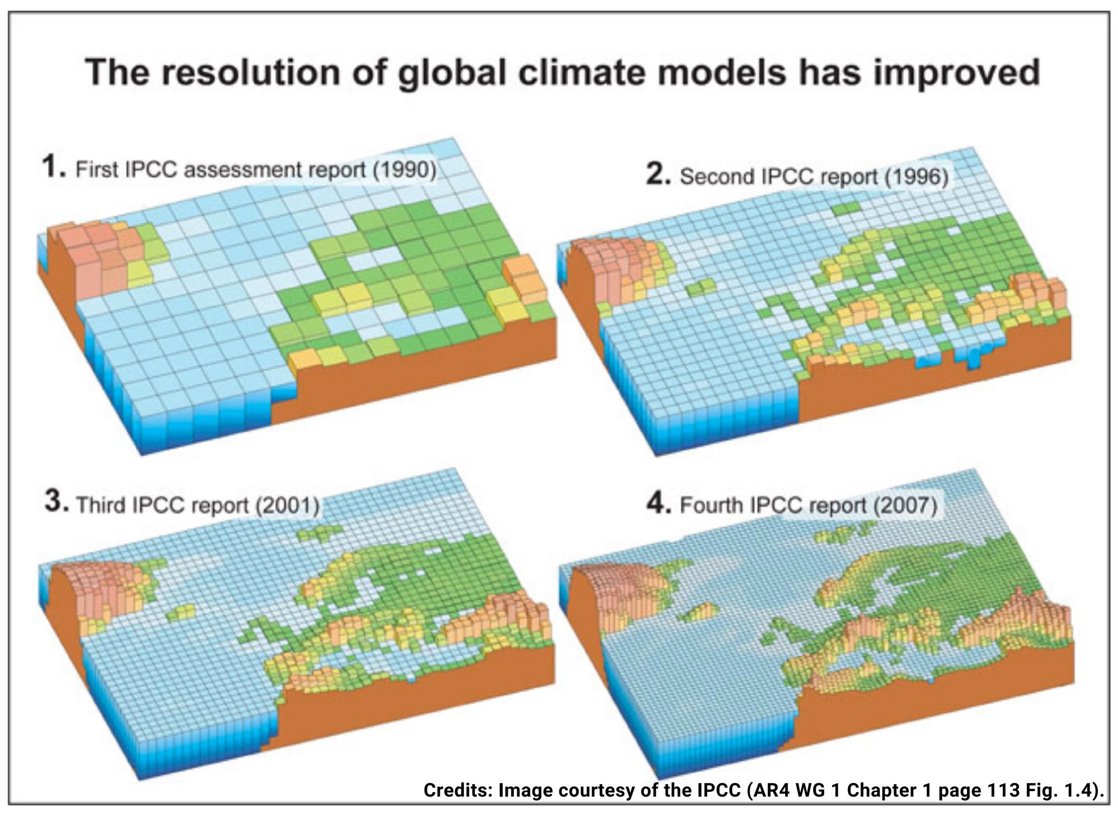


1. Introduction

Why caring about the effective resolution?

The effective resolution of a regional climate model (RCM) provides an insight into the scale at which the model's outputs are most trustworthy and can be considered physically meaningful. It helps scientists and modelers interpret outputs correctly and serves as a guide for improvements in model architecture.

Objective:

Create an open-source, community managed tool for robust diagnostics of the effective resolution of dynamical models.

2. Method Overview

Step 1: Generate the spectral coefficients of the 2 dimensional meteorological field.

$$F(m,n) = 2D\_DCT[f(i,j)]$$

Step 2: Compute the power spectra.

$$\sigma^2(m,n) = \frac{F^2(m,n)}{N_i N_j}$$

Step 3: Compute the normalized 2D wavenumber, while retaining only the resolved modes (Nyquiest period)

$$\alpha(m,n) = \sqrt{\frac{m^2}{N_i^2} + \frac{n^2}{N_j^2}} \text{ with } 0 < \alpha < 1$$

Step 4: Each 2D wavenumber band can be connected to a spatial scale/wavelegth.

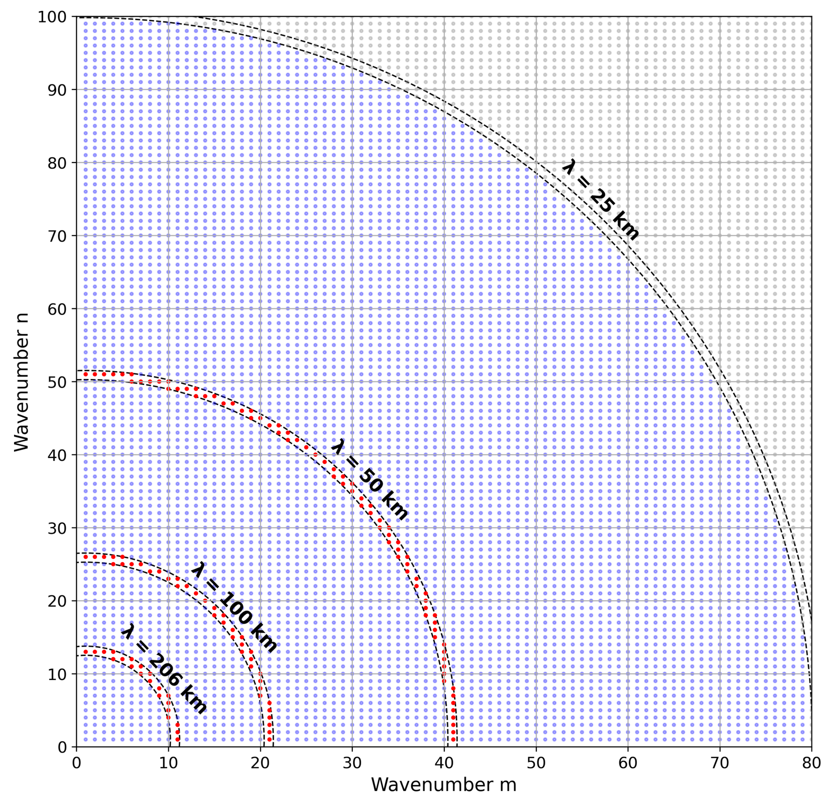
$$\lambda = \frac{2\Delta x}{\alpha}$$

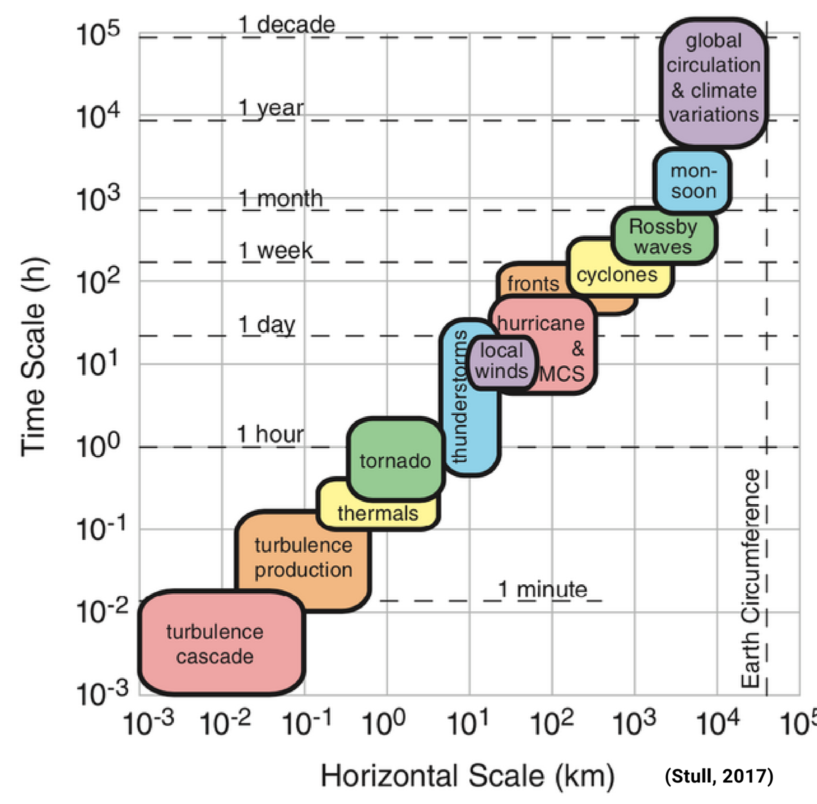
Step 5: To quantify the amount of information or power contained in a given wavelength, we add up all contributions contained within two ellipses band.

$$\alpha(m,n) = \frac{\sqrt{m^2+n^2}}{\min(N_i,N_j)} \qquad \alpha(m,n) + \Delta\alpha = \frac{\sqrt{m^2+n^2}+1}{\min(N_i,N_j)}$$

$$Var(\lambda) = \sum_{\alpha(m,n)}^{\alpha(m,n)+\Delta\alpha} \sigma^2(m,n)$$

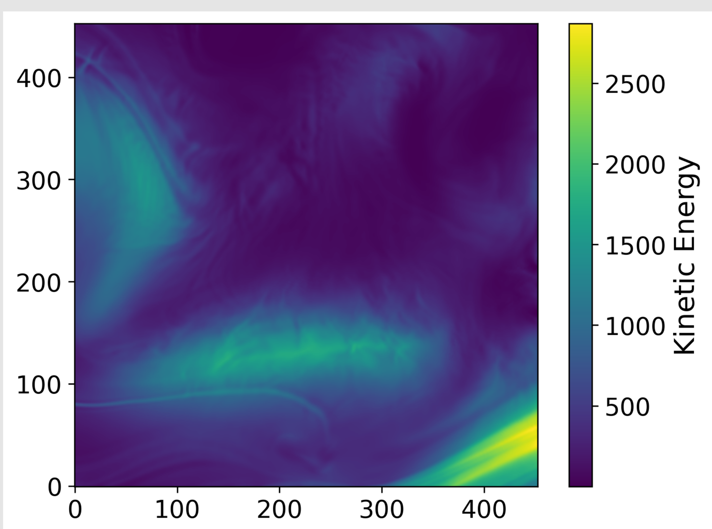
Credits for developing the method: Denis, B., Côté, J., Laprise, R., 2002. Spectral Decomposition of Two-Dimensional Atmospheric Fields on Limited-Area Domains Using the Discrete Cosine Transform (DCT). Mon. Wea. Rev. 130, 1812–1829. https://doi.org/10.1175/1520-0493(2002)130<1812:SDOTDA>2.0.CO;2



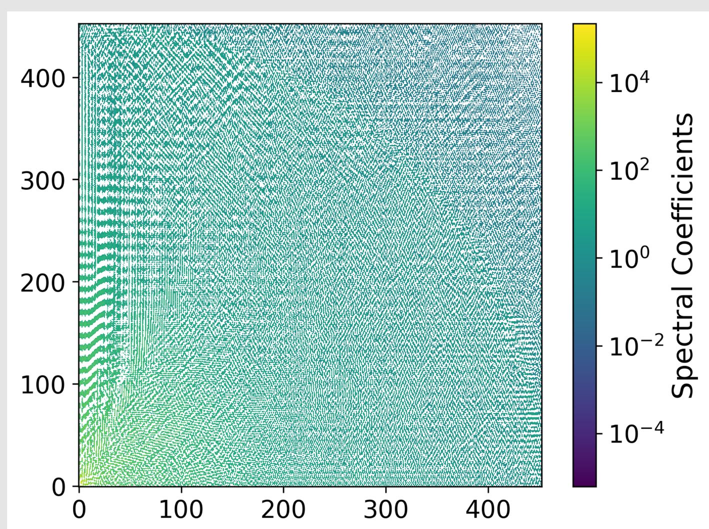


3. Application: compute effective resolution

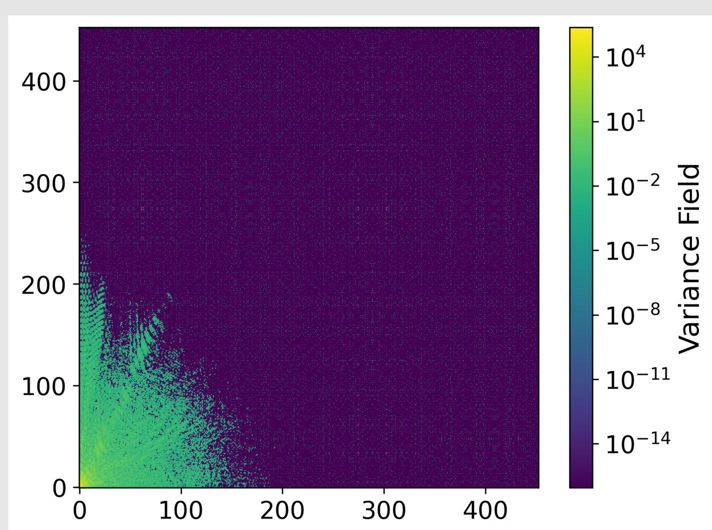
Compute the instantaneous 2D Kinetic energy field at given height



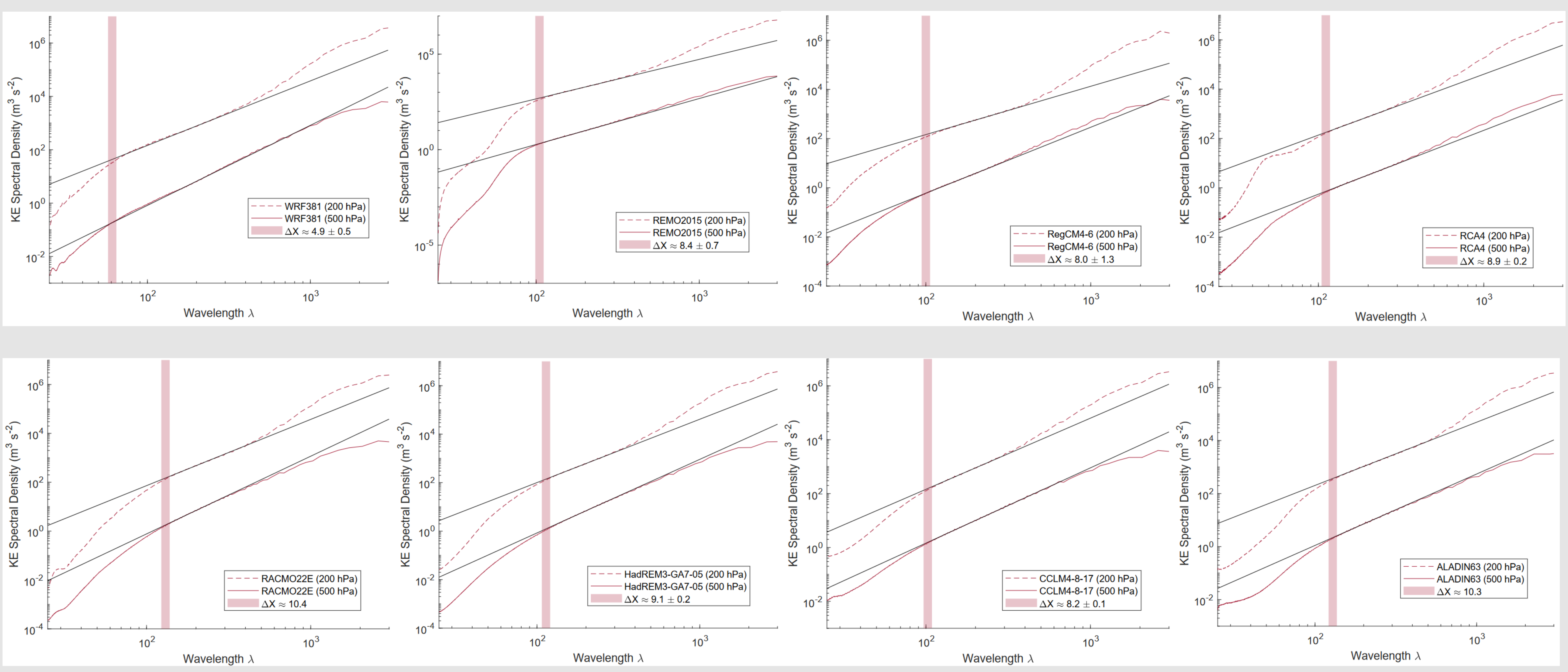
Compute the spectral coefficients F(m,n)



Compute the variance field



4. Effective resolution of state of the art RCMs



5. Conclusion

Today, there is a large spread in the effective resolution of current RCMs, ranging between 5-10Δx.

In order to solve all mesoscale phenomena, including thunderstorms, complex topography flows and local winds, it is required to achieve an effective resolution of 2-20 km.

To reach this target, and lower the associated computational and storage costs, it may be more efficient to improve the models architecture, than increasing the nominal resolution.

Provide your feedback

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