Atmospheric kinetic energy spectra from high-resolution GEM models

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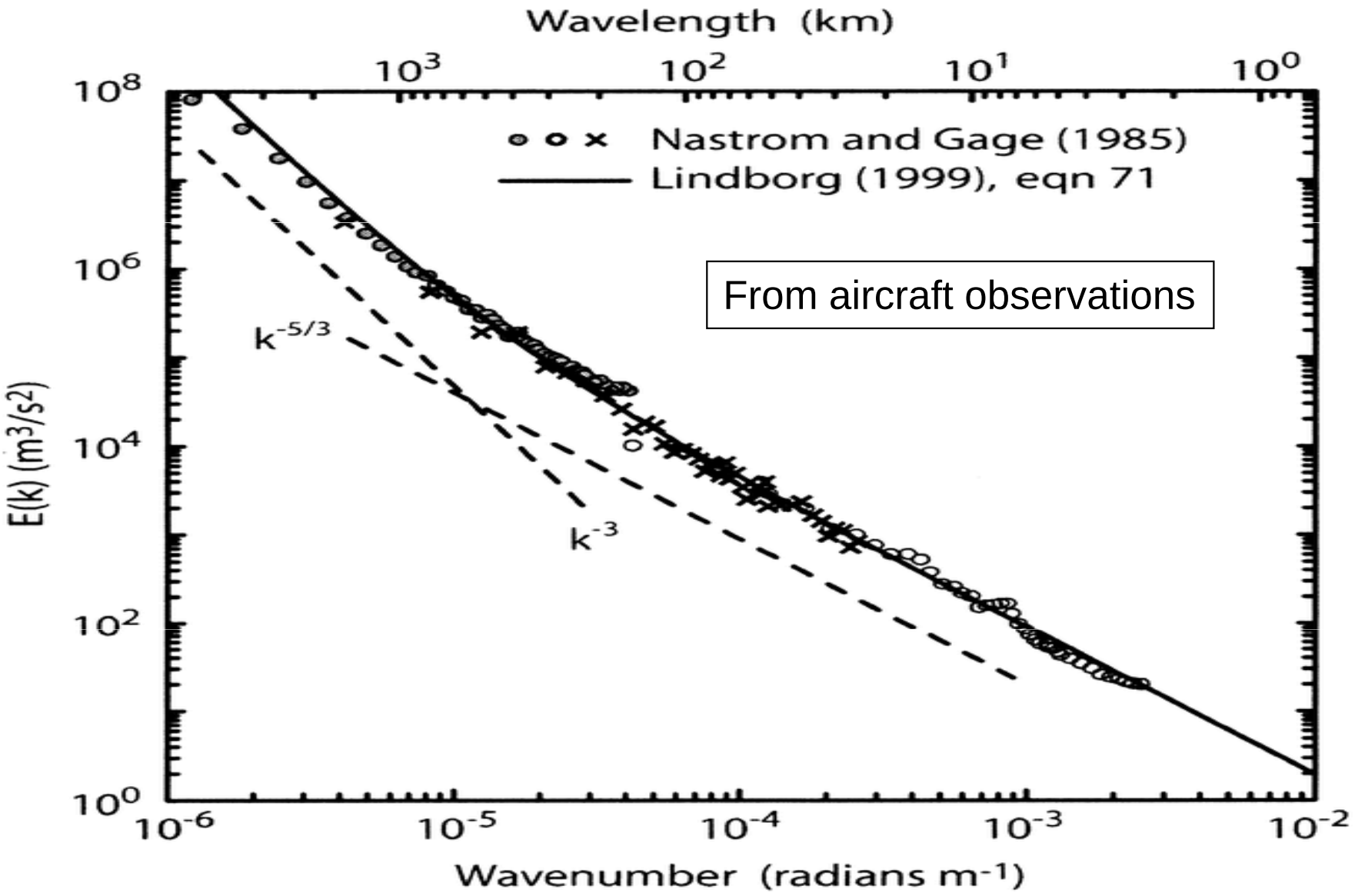
Outline

- Introduction
  - What we are looking for
- Methodology
- Results
  - -3 and -5/3 spectral slopes
  - Effective resolution
  - Spin-up time
  - Diurnal cycle
  - Seasonal and Domain impacts
  - Vertical velocity vs total KE
  - GEM-REG 15 km vs GEM-LAM 2.5 km
- Conclusions

Introduction



From Skamarock, MWR 2004

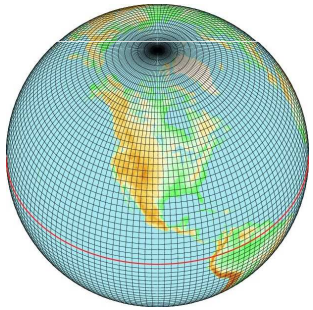
Methodology

- Spectral decomposition using 2D-DCT (Denis *et al.* 2002, MWR)
- Average between 700-200 hPa
- Season averages
  - Summer: June-July-August 2006
  - Winter: January-February-March 2007
- Domains (1000x1000 km^2) over two Canadian regions
  - West : British-Colombia
  - East: Southern Ontario-Quebec
- CMC-RPN Models
  - GEM-REG 15 km
  - GEM-LAM 2.5 km

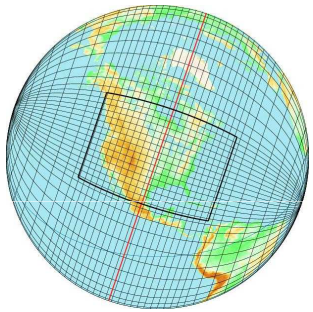
Methodology – Model description

GEM = Global Environmental Model

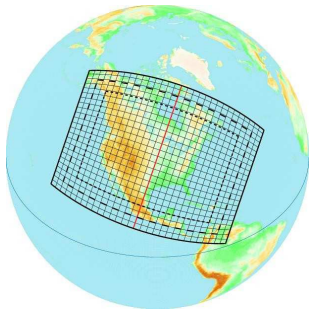
CMC multi-scale model



- Global constant resolution (regular lat-lon grid) (GEM-Global)
  - Seasonal forecasts / Climate simulations (100 km)
  - Medium-range EPS (100 km)
  - Medium-range deterministic forecasts (33 km)



- Global variable resolution (stretched grid)
  - North America climate simulations (55 km)
  - Short-range deterministic forecasts (GEM-Regional 15 km)



- Limited-area (LAM) constant resolution lat-lon grid
  - North America climate simulations (15-55 km)
  - Short-range EPS (33 km)
  - Short-range high-res. deterministic forecasts (GEM-LAM 2.5/1.0 km)
  - Urban emergency response (250 m)

Methodology – Model descriptions

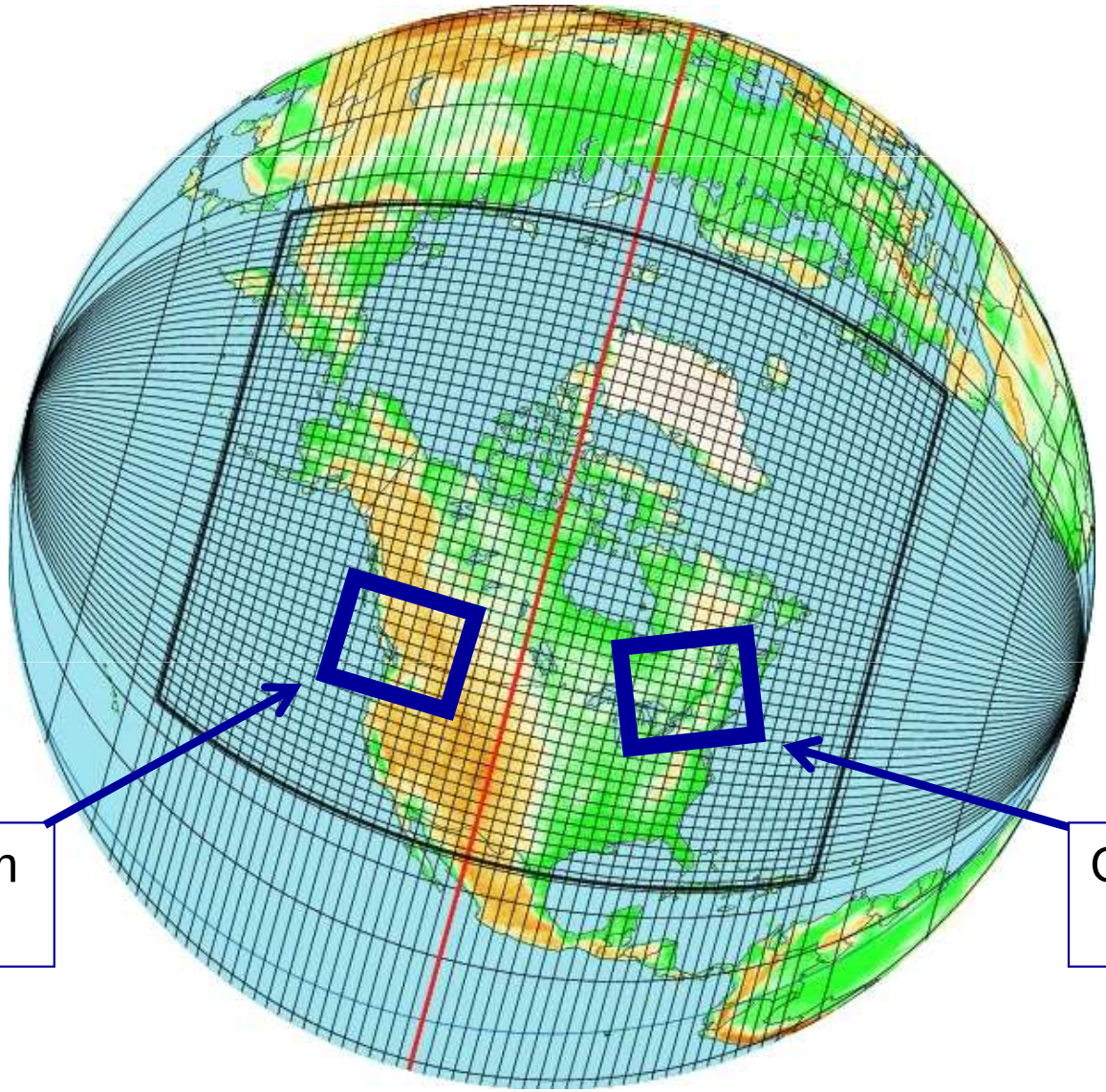
GEM characteristics (2006-2007 version)

- 3D Semi-lag, fully implicit, two-time level (Crank-Nicholson)
- Arakawa-C horizontal grid
- 58 unstaggered levels / top 10 hPa (Laprise mass hybrid vertical coordinate)

		GEM-REG 15 km	GEM-LAM 2.5 km
Time step	:	7.5 min.	1 min.
Horizontal Diffusion	:	implicit $del^6(0.02)$	implicit del^4 (0.2)
Non-hydrostatic ?	:	no	yes, fully compress.
Deep convection param.	:	Kain-Fritsch	- none -
Shallow convec. Param.	:	Kuo-transient	Kuo-transient
Grid scale condensation	:	Sundquist	Kong & Yau micro.
Assimilation	:	3D-VAR	IC from GEM-REG

Methodology – Model domains

GEM-REGIONAL 15 km

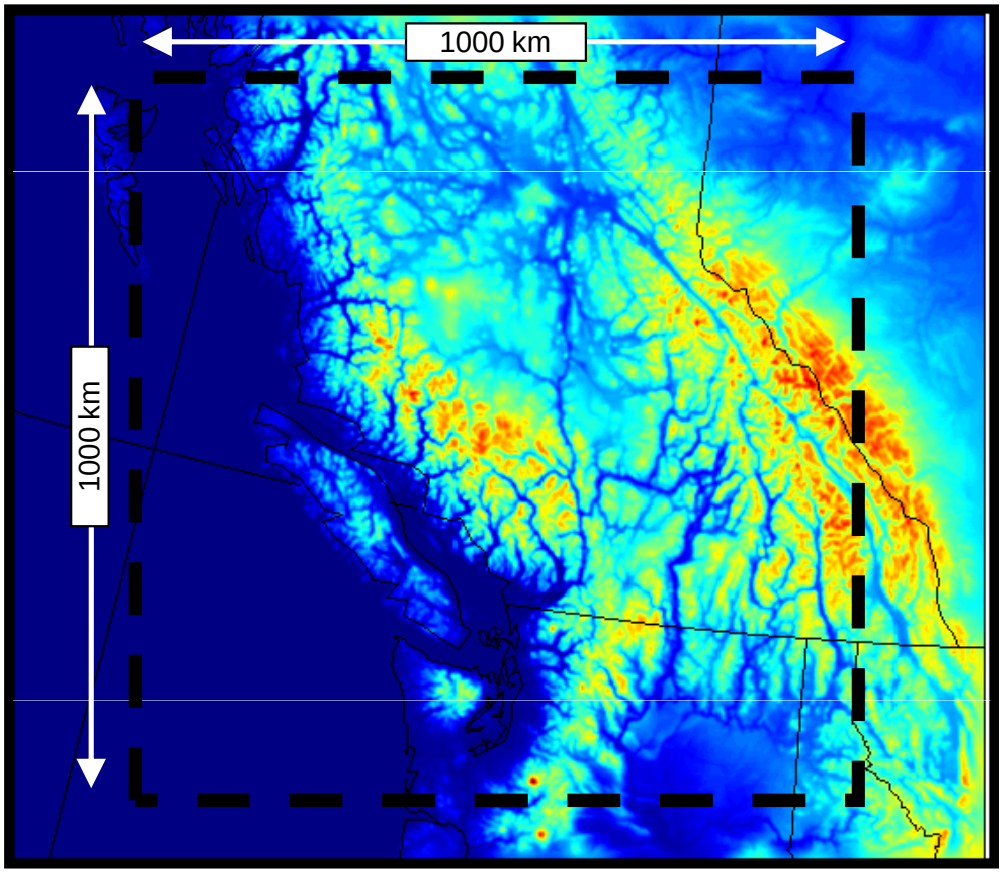


GEM-LAM 2.5 km
'West'

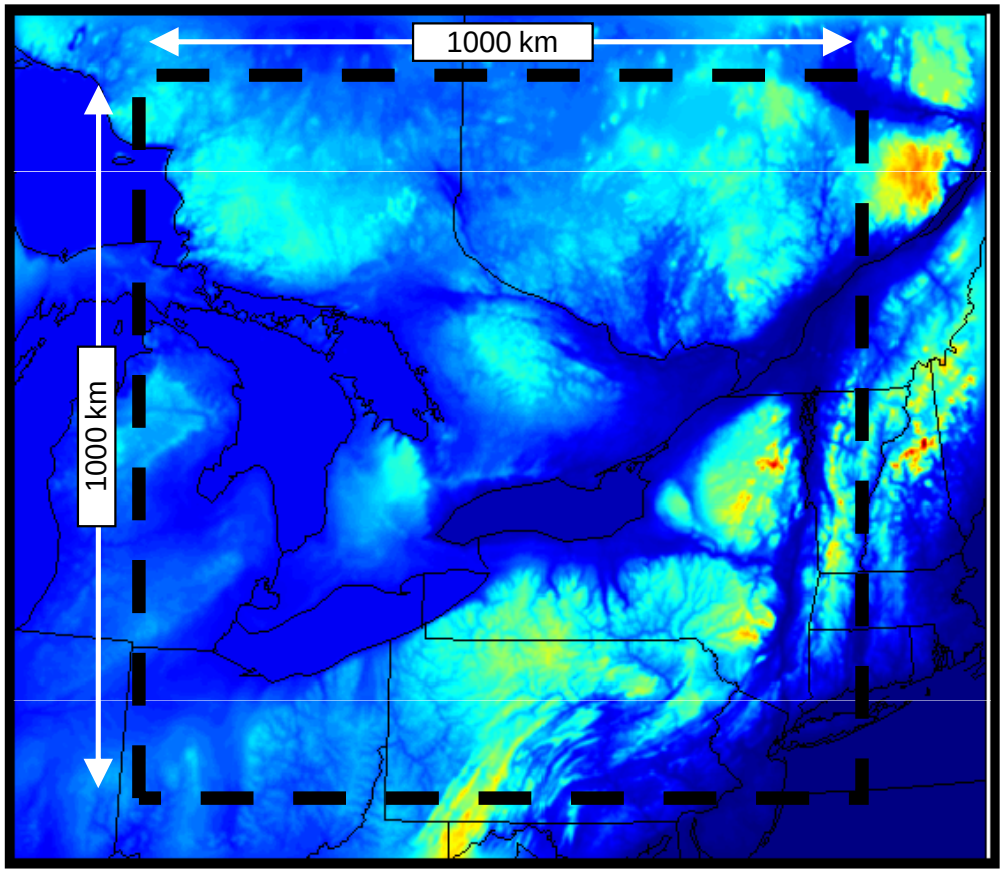
GEM-LAM 2.5 km
'East'

Every 10th grid point shown

Methodology – Model domains

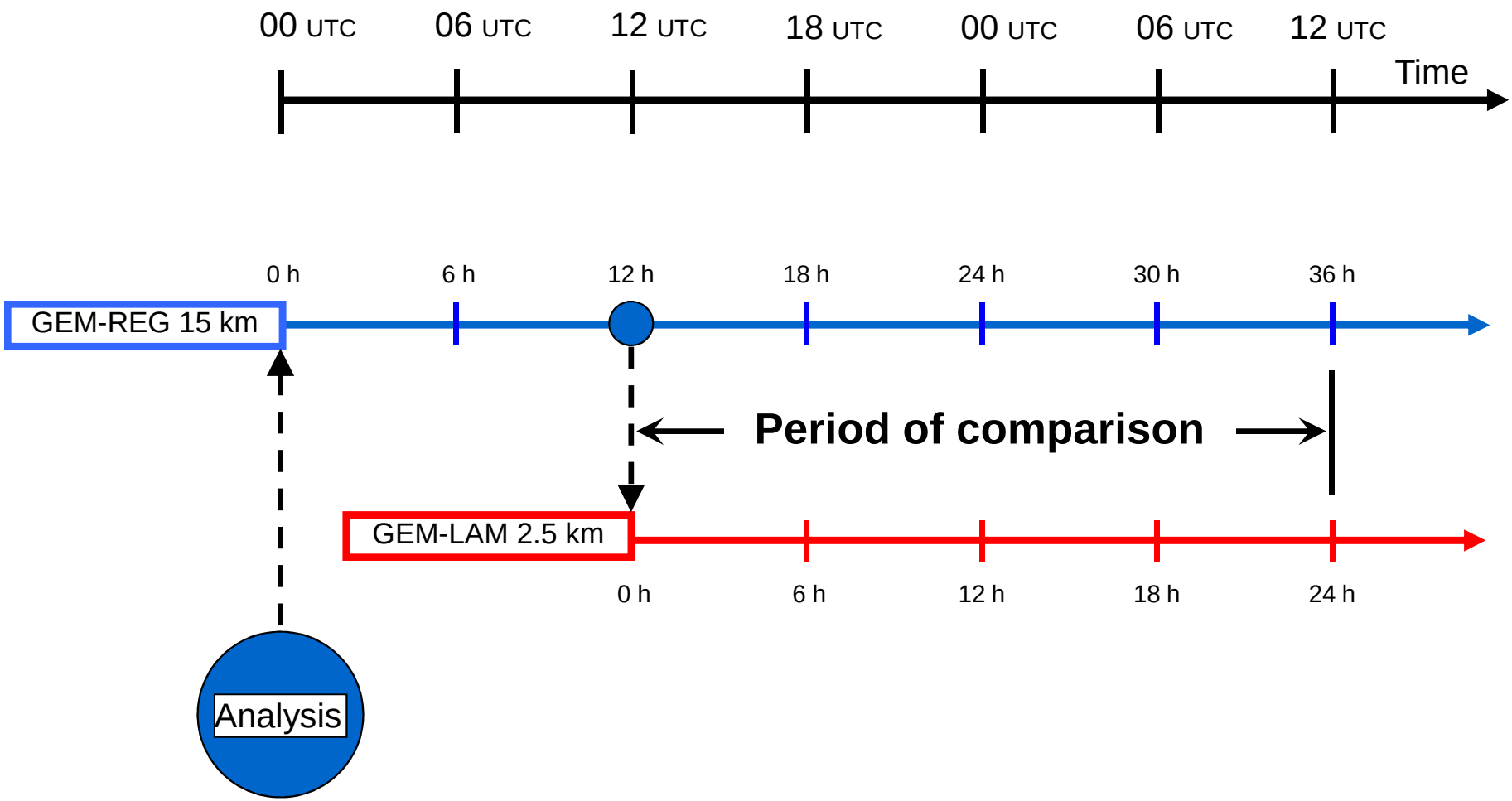


West domain

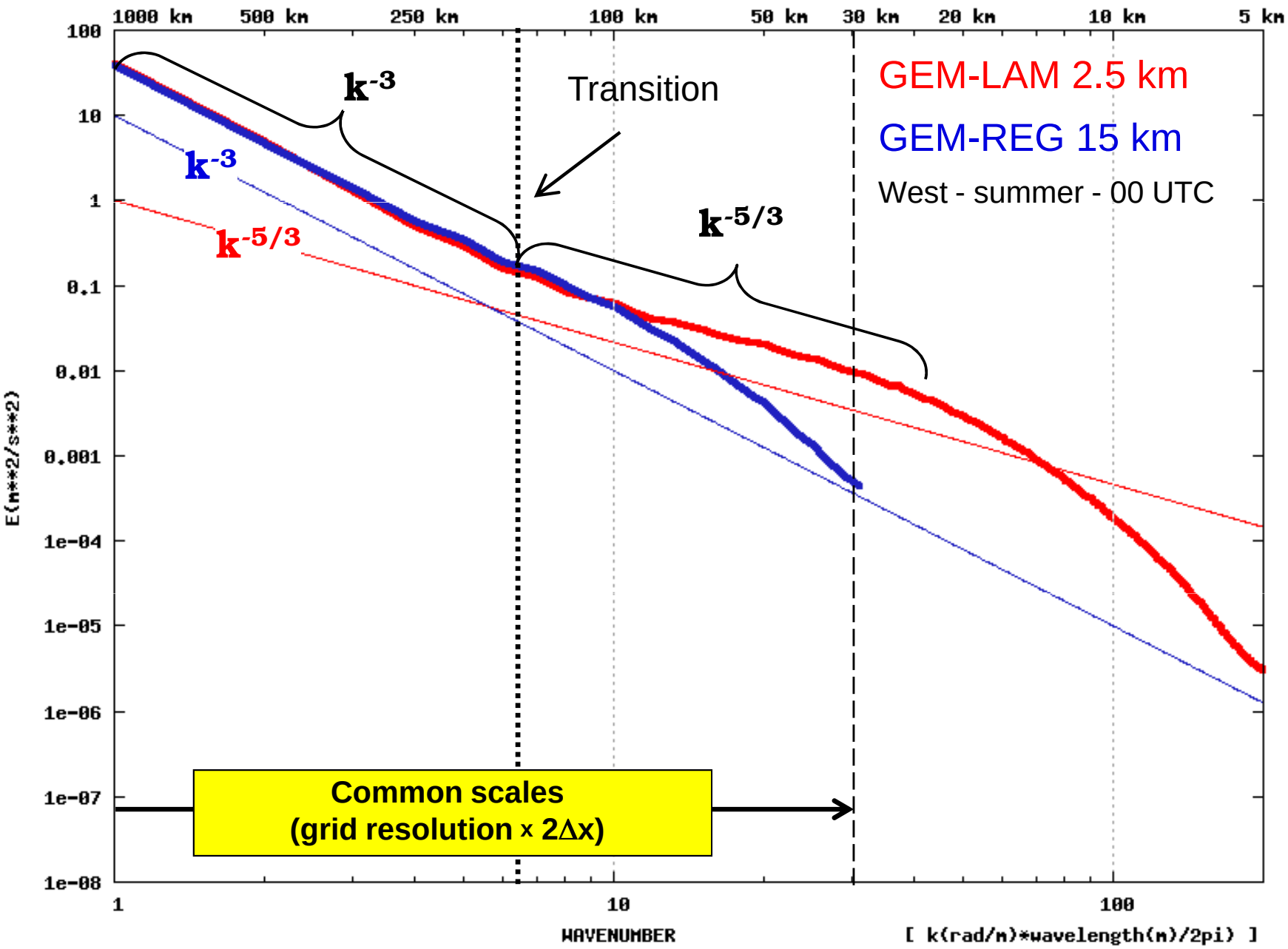


East domain

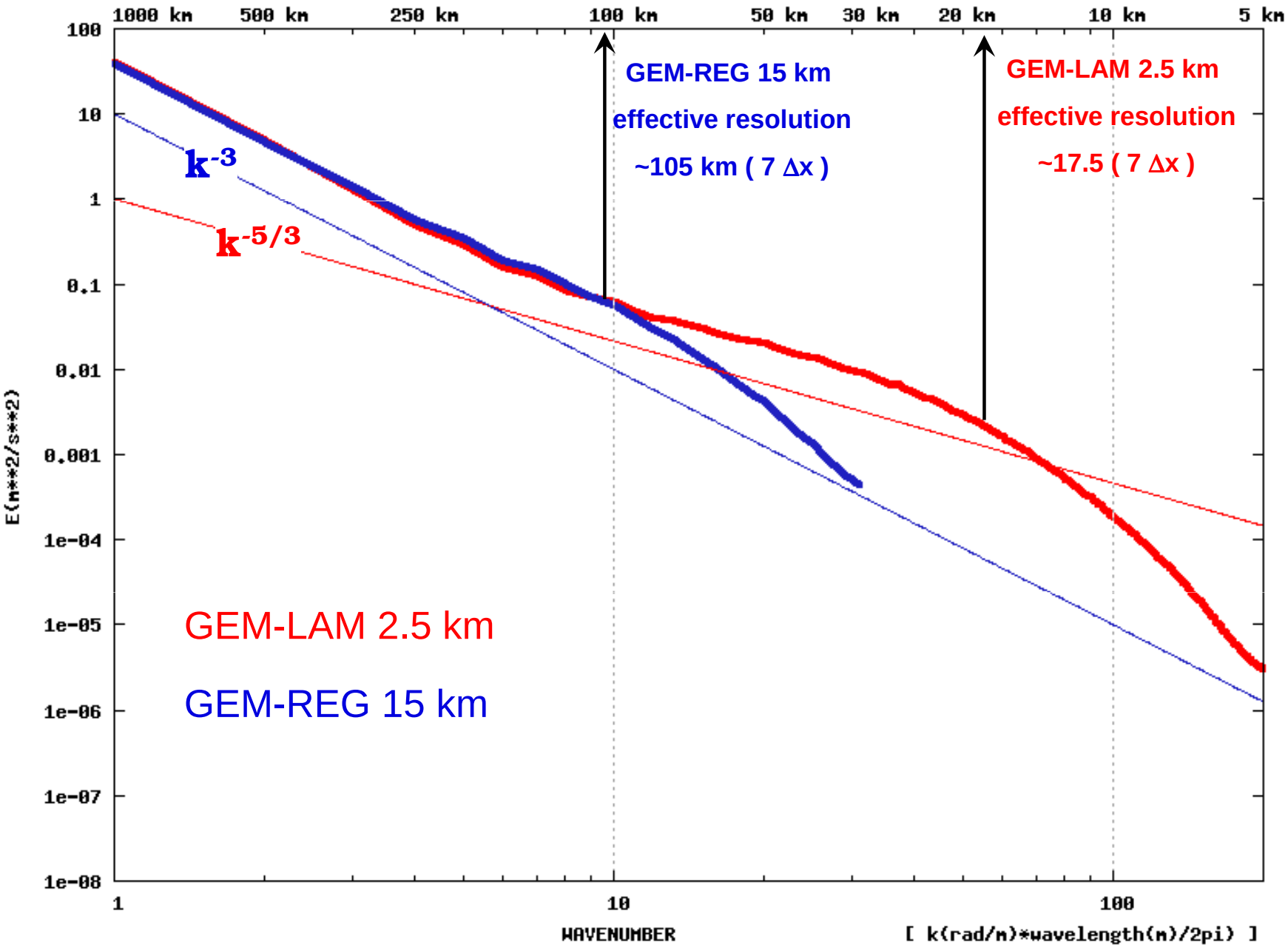
Methodology – model runs set up



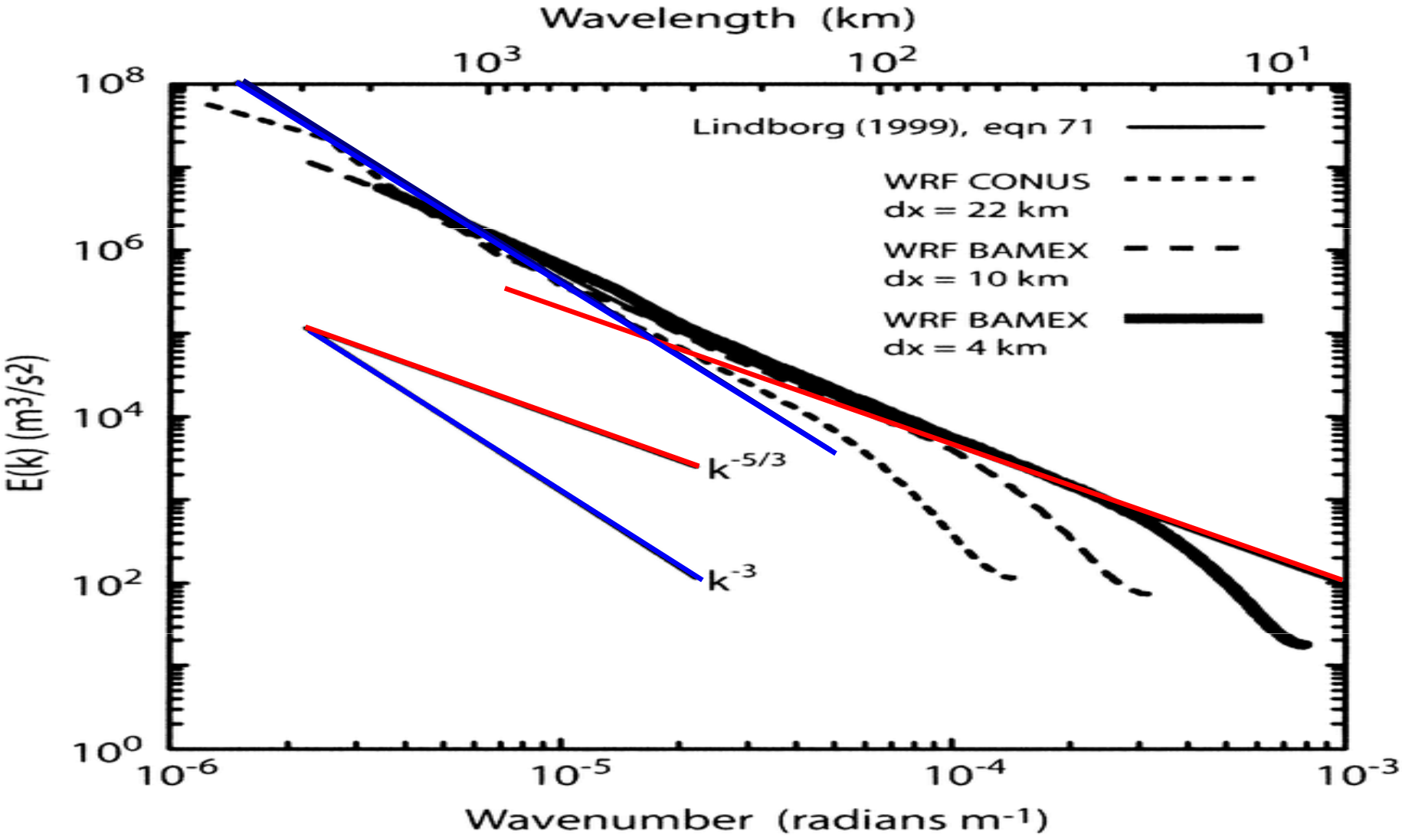
Results: -3 and -5/3 slopes



Results: effective resolution

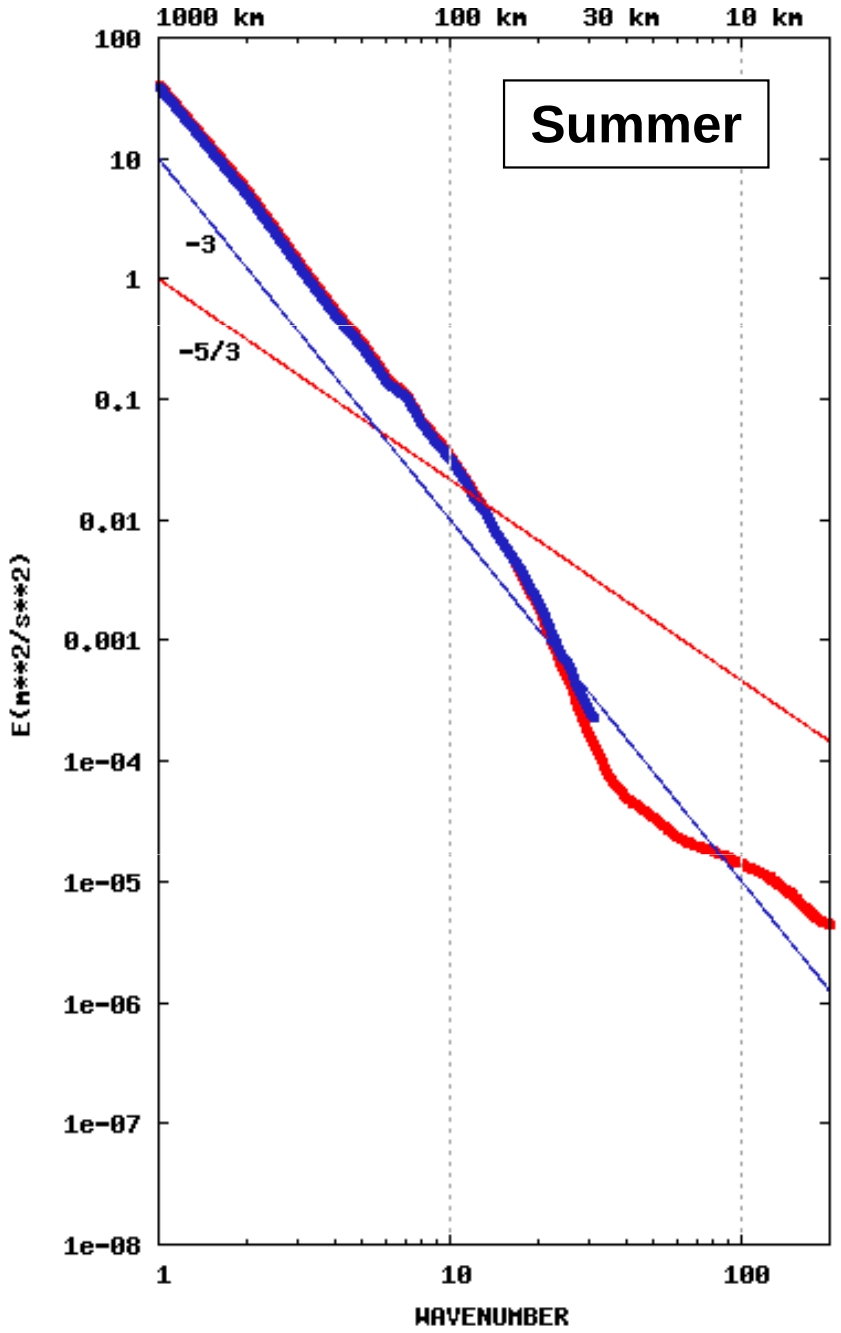


Results: Spectra from WRF



From Skamarock, MWR 2004

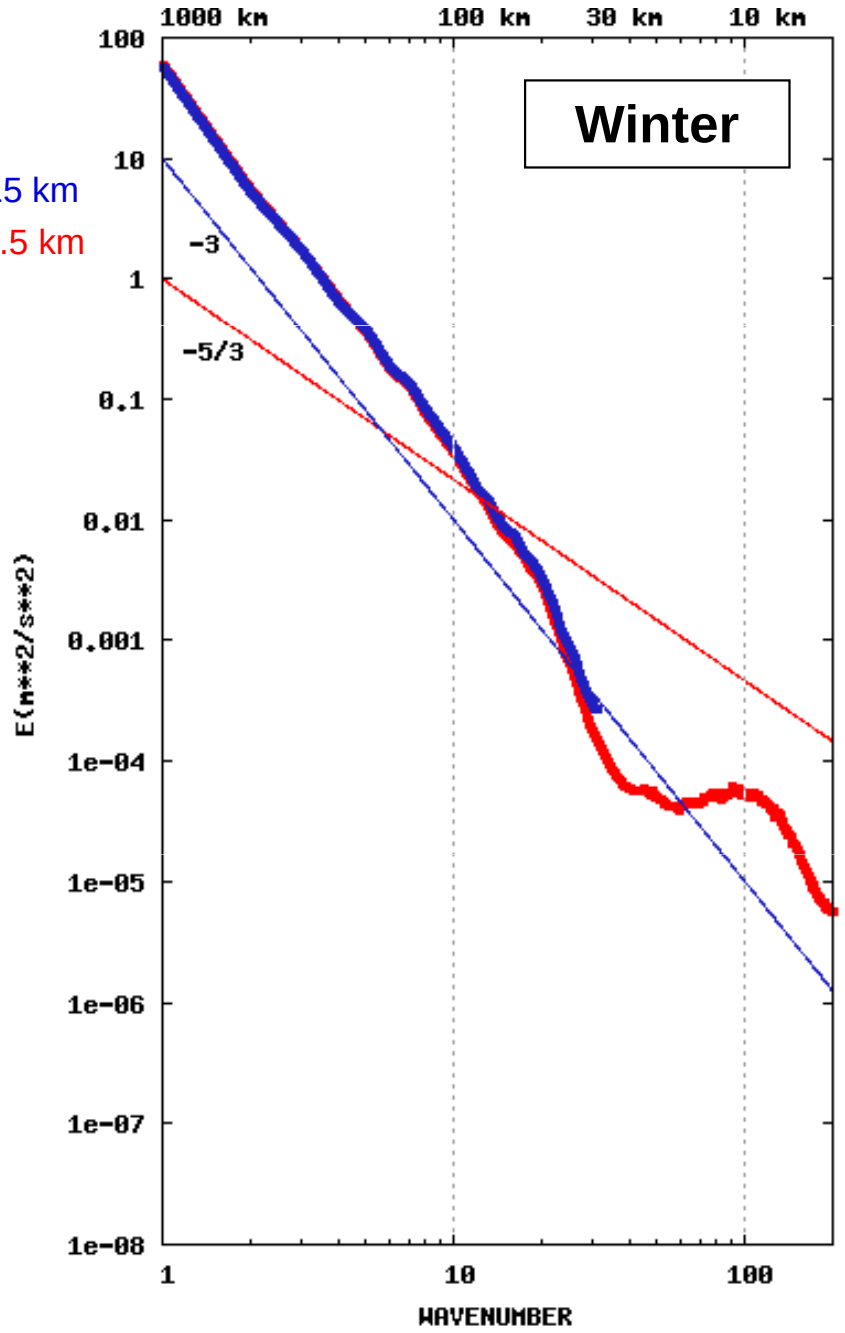
Results: spin-up



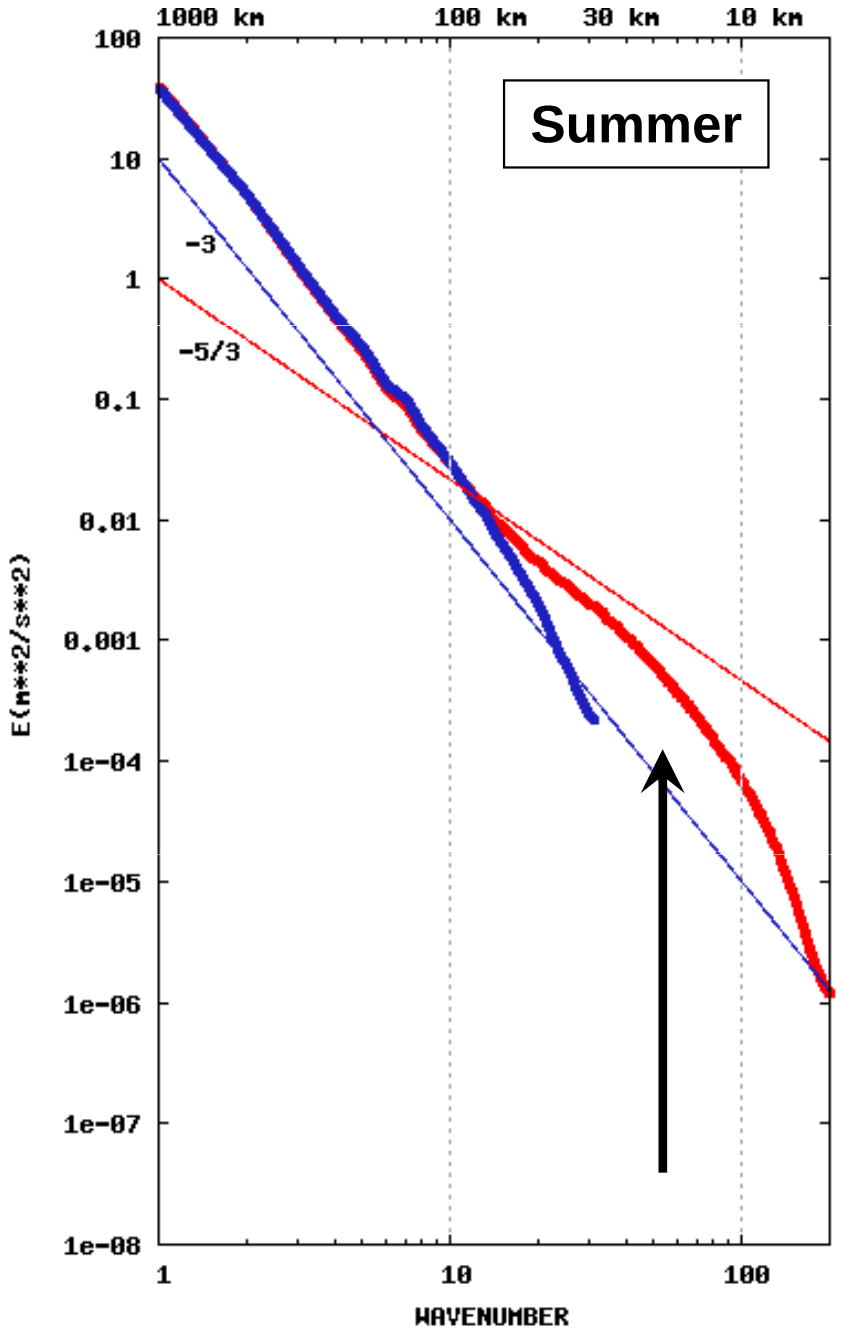
12Z

GEM-REG 15 km

GEM-LAM 2.5 km



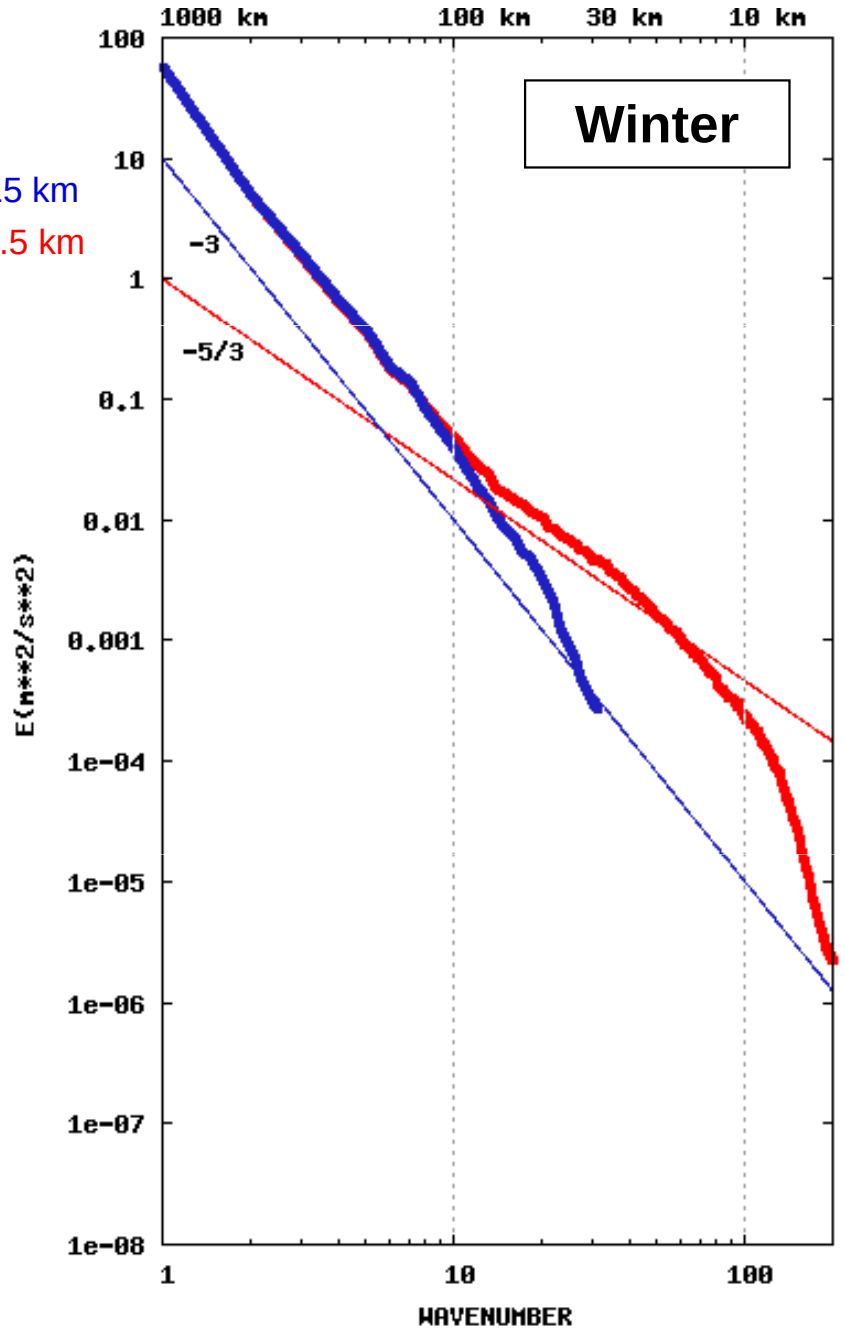
Results: spin-up



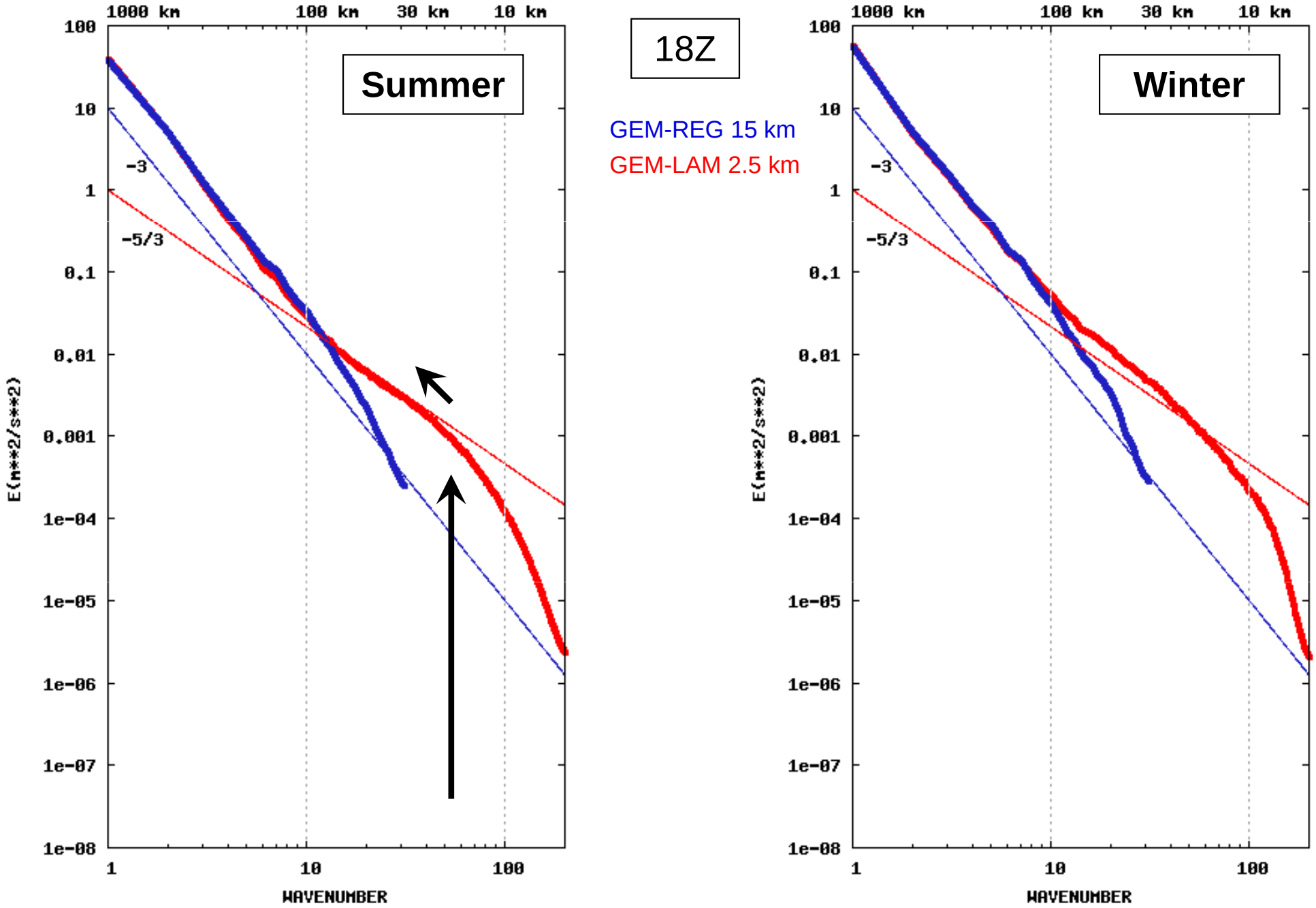
15Z

GEM-REG 15 km

GEM-LAM 2.5 km



Results: diurnal cycle



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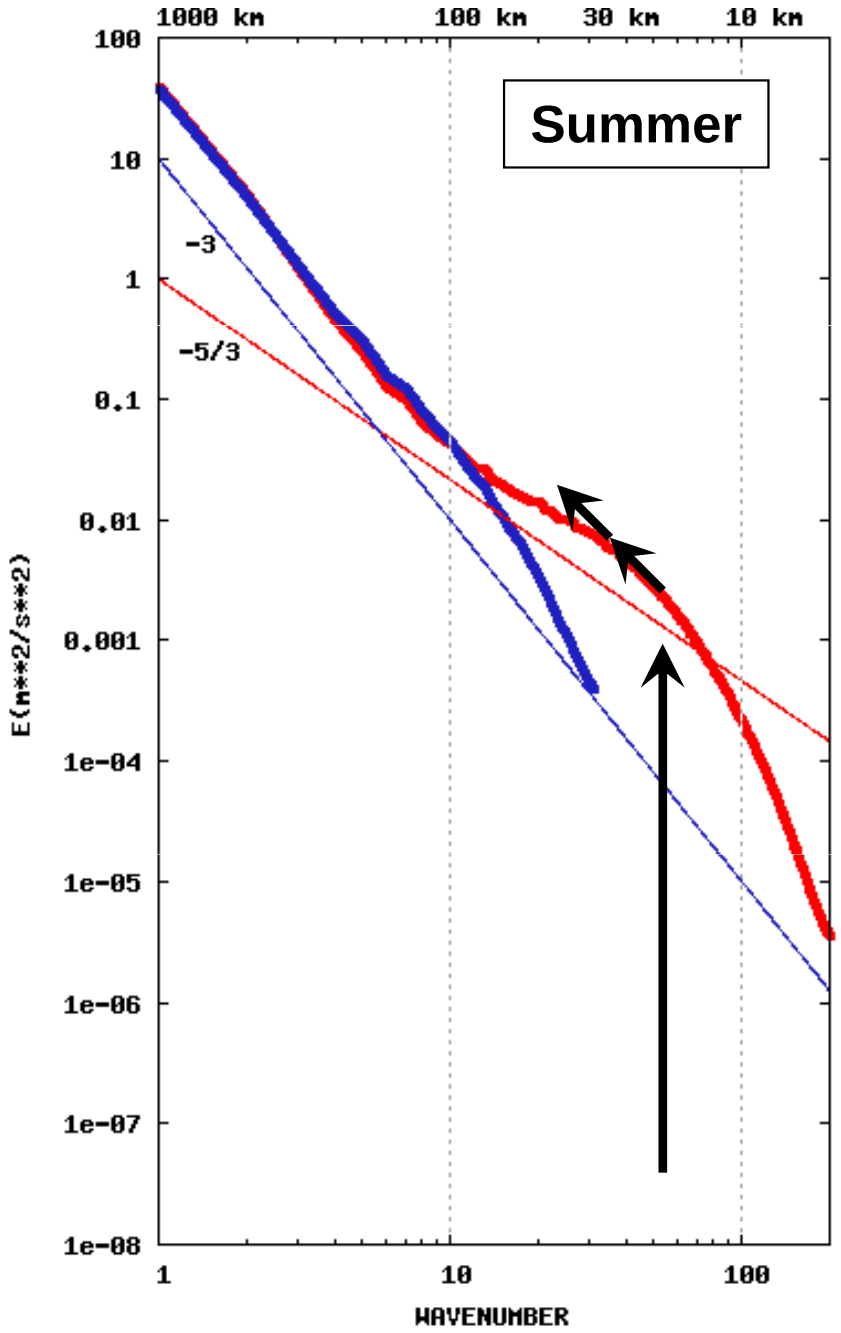

21Z

GEM-REG 15 km

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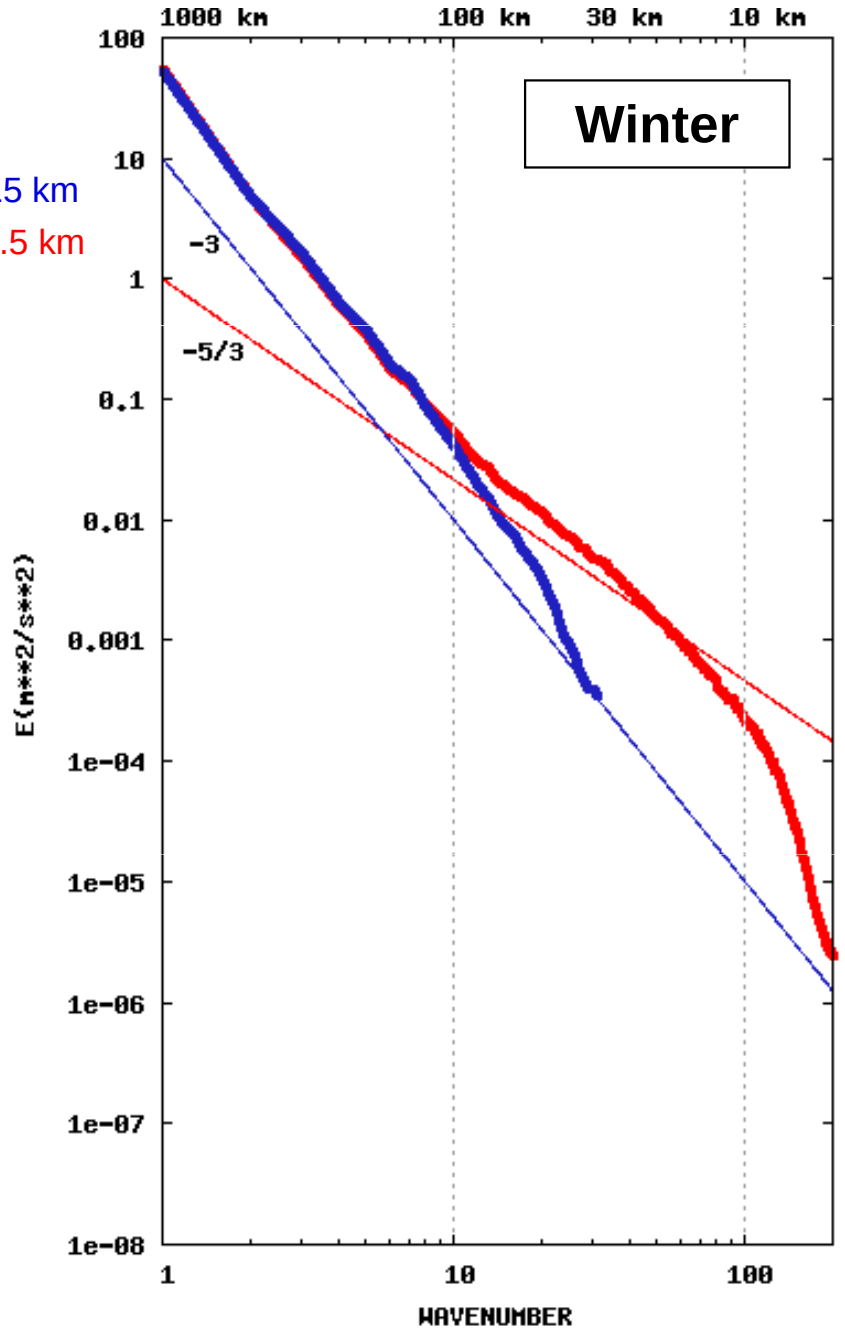
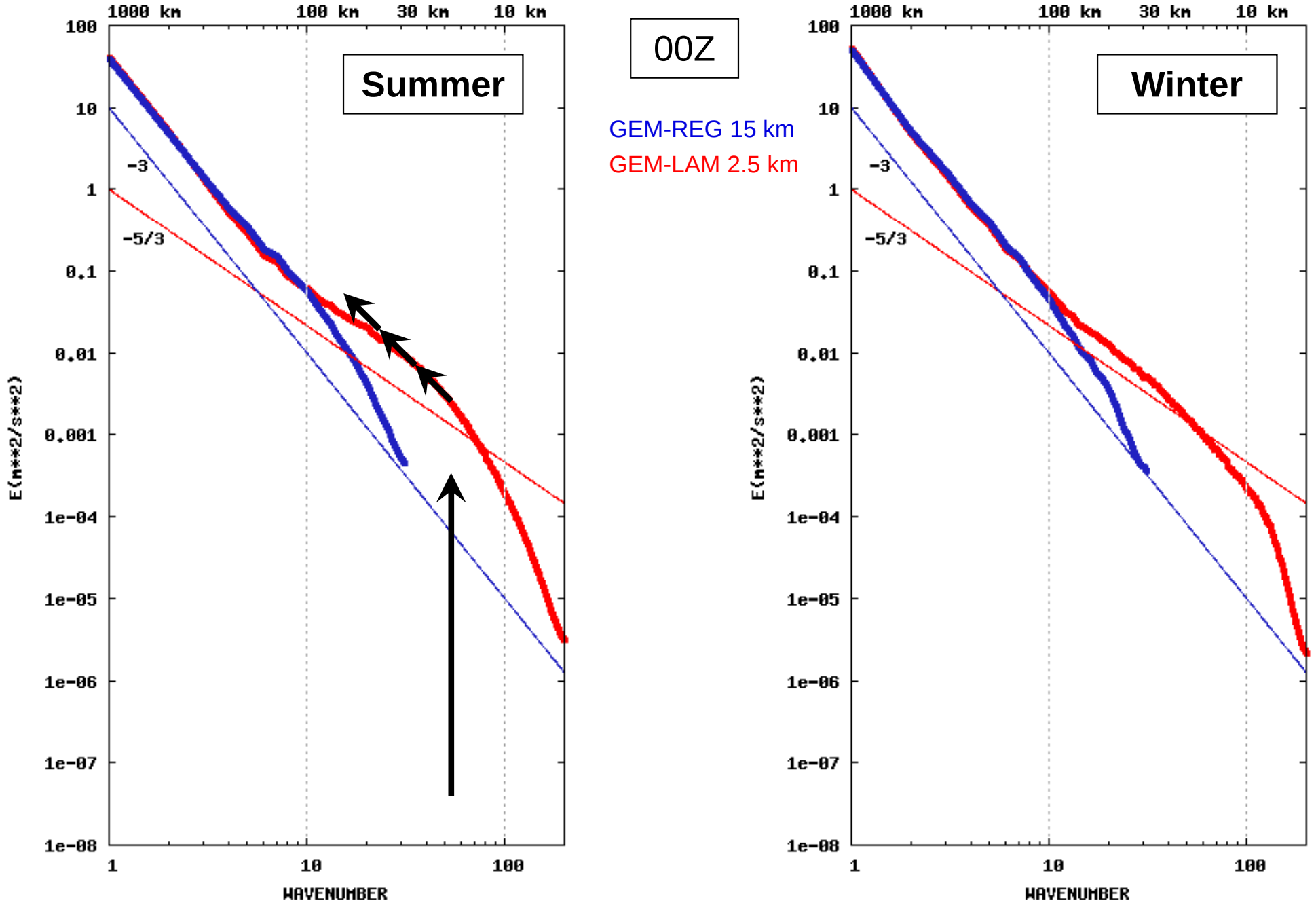
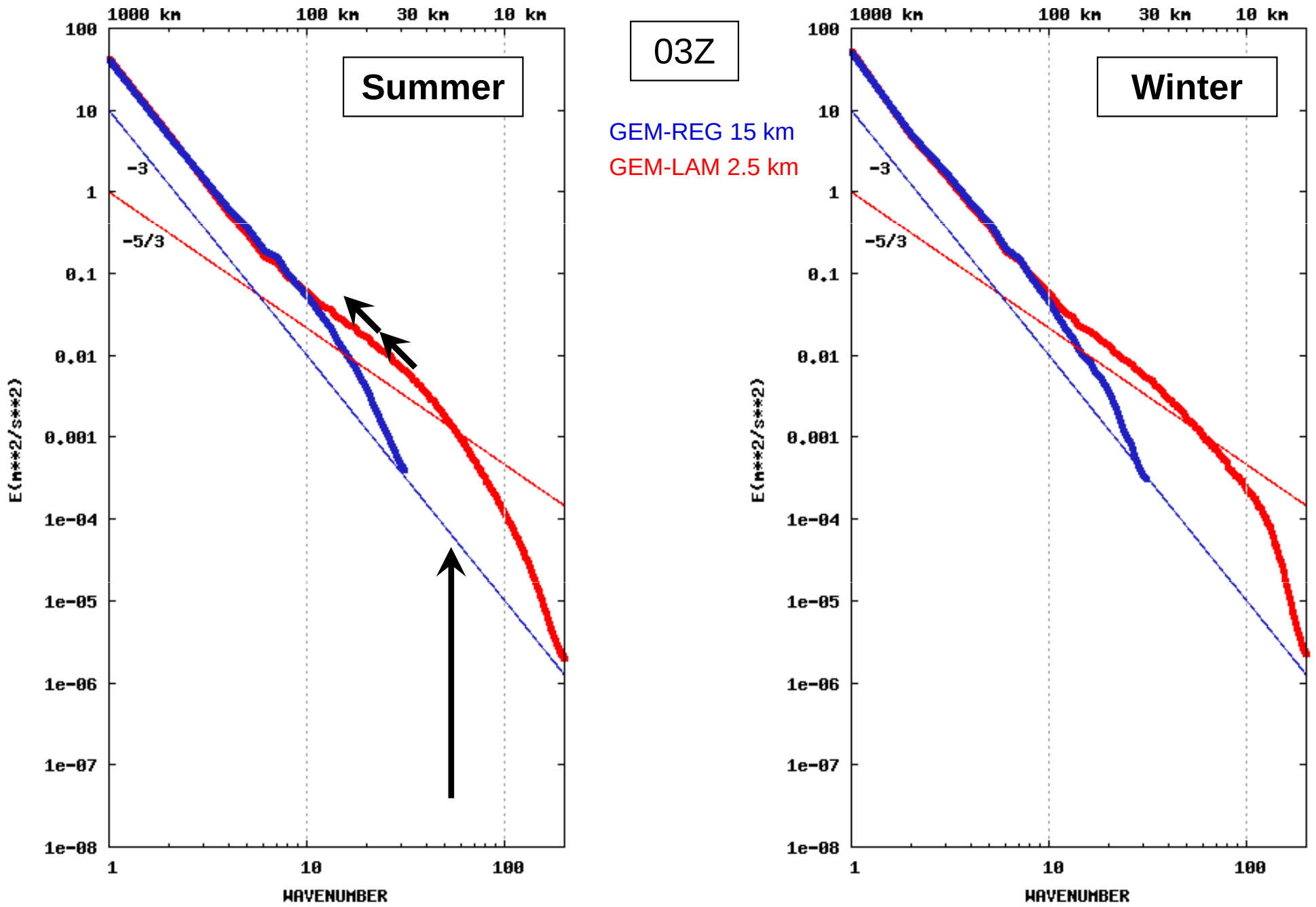


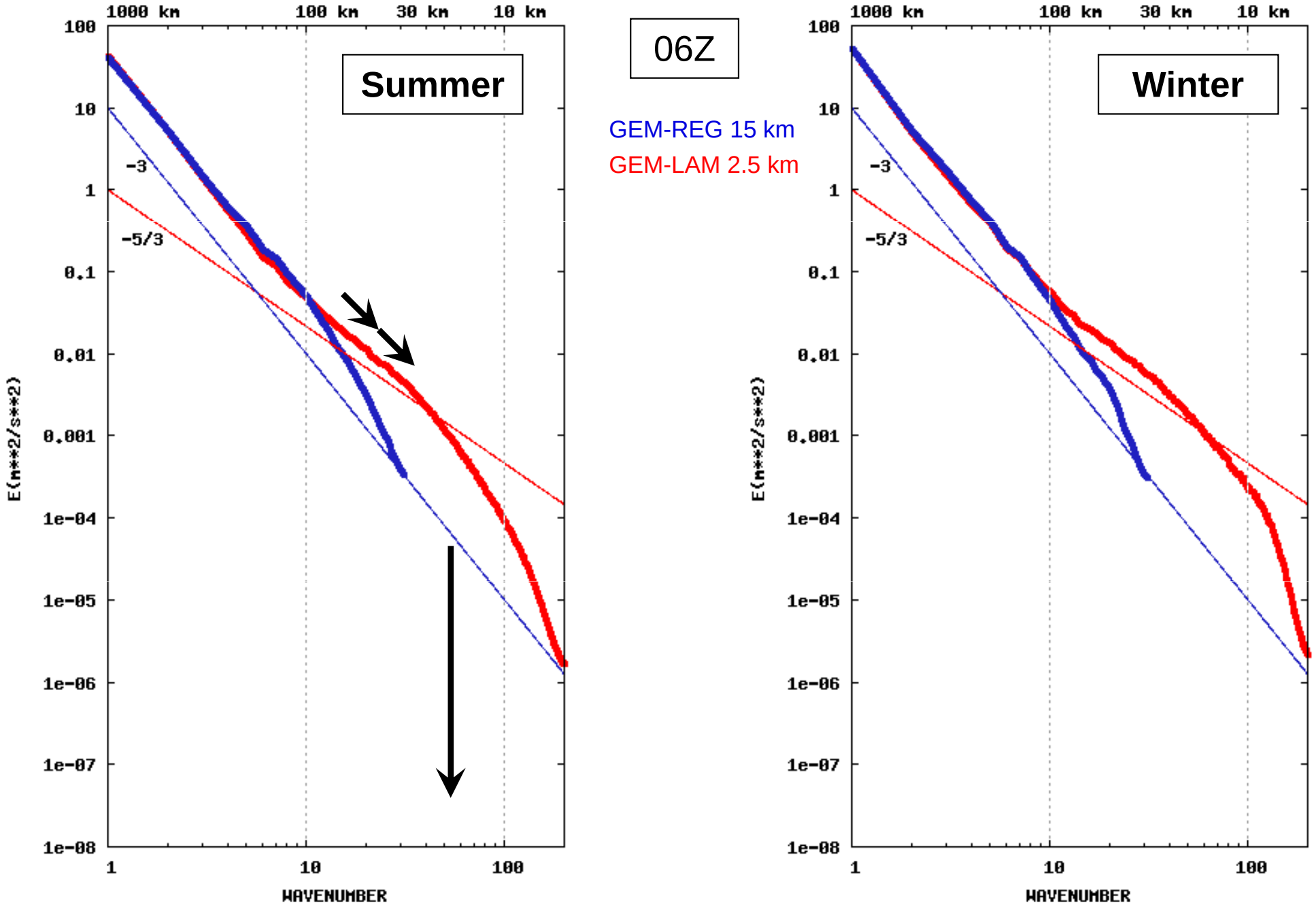
Results: diurnal cycle



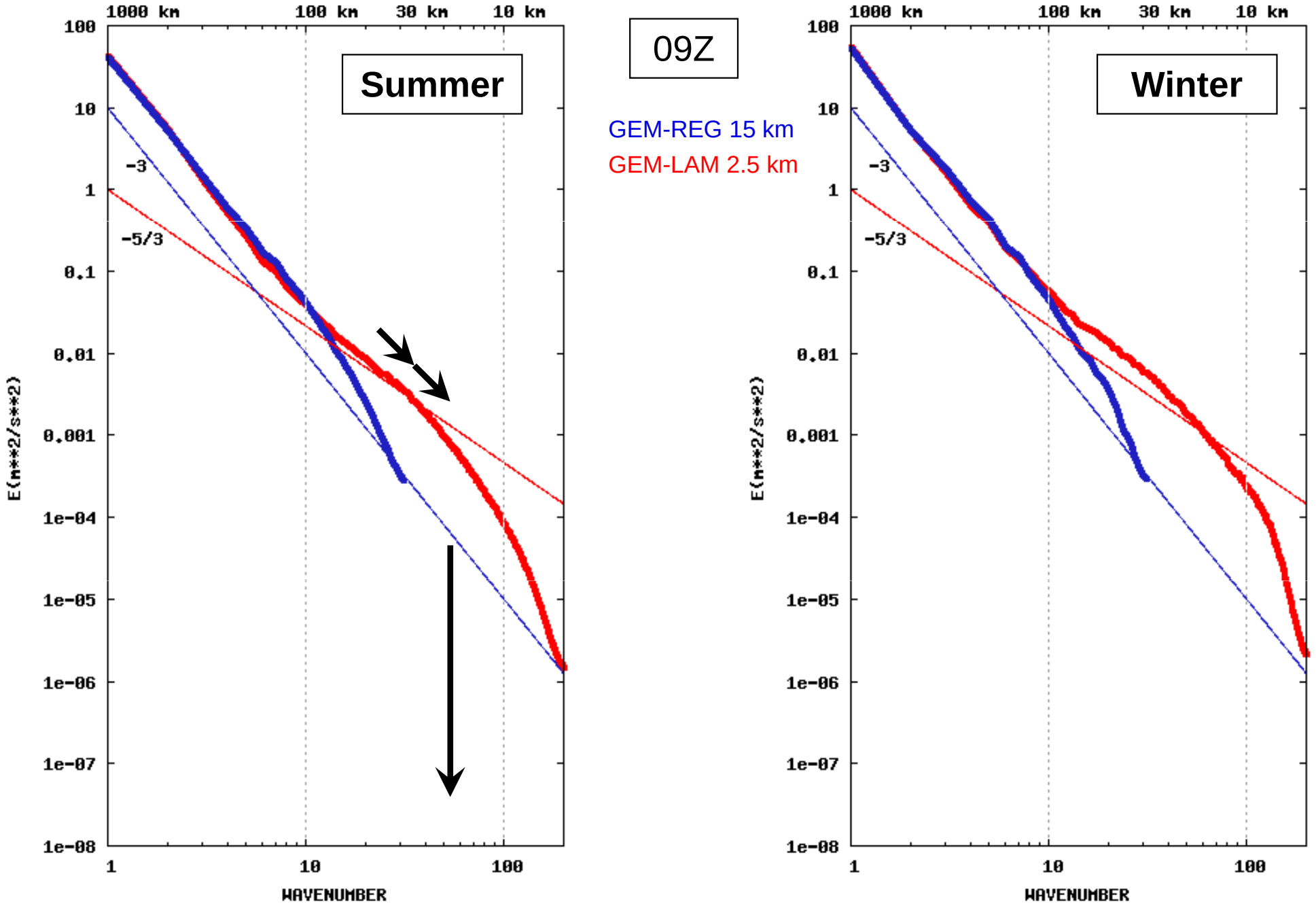
Results: diurnal cycle



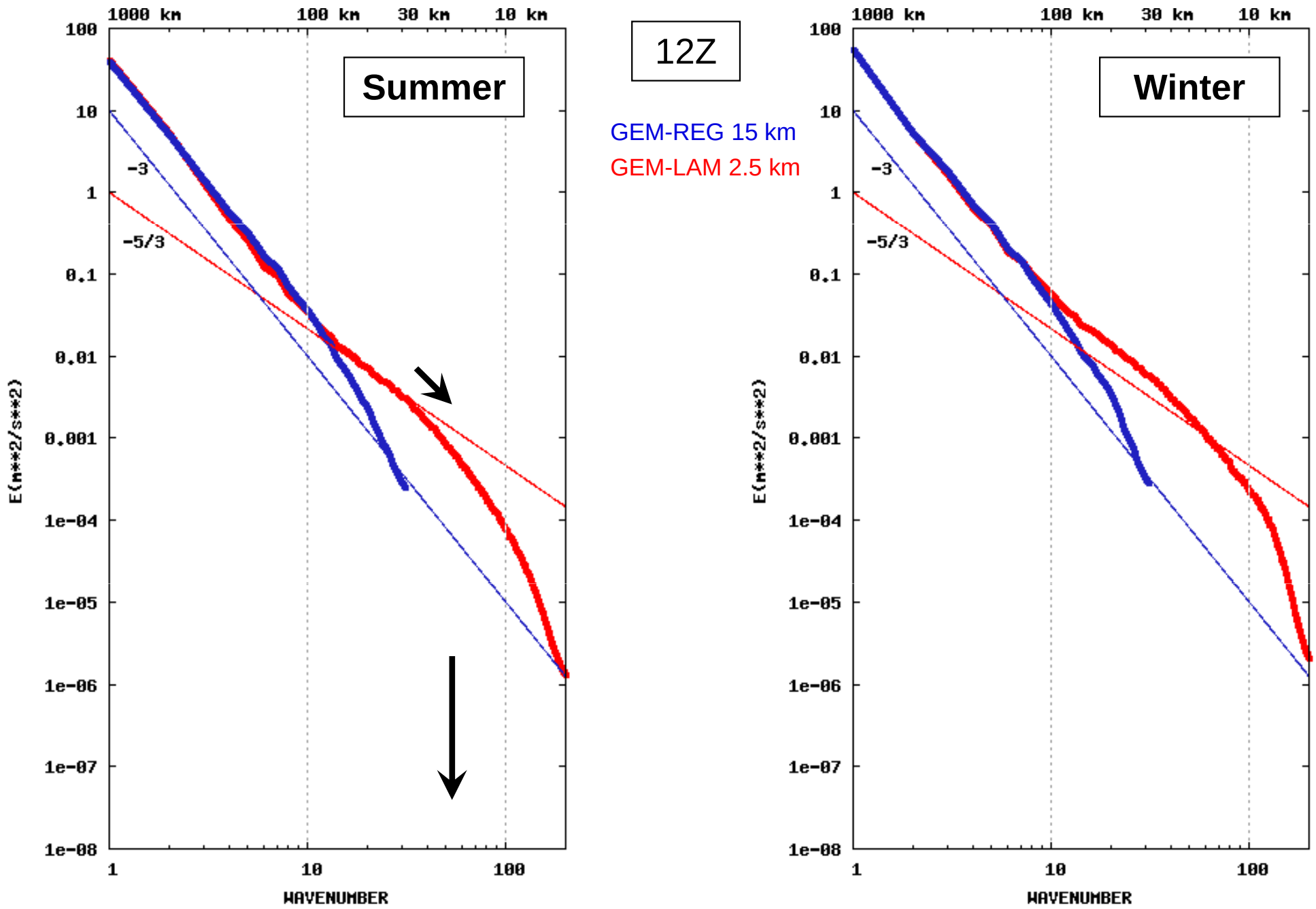
Results: diurnal cycle



Results: diurnal cycle



Results: diurnal cycle (bis)



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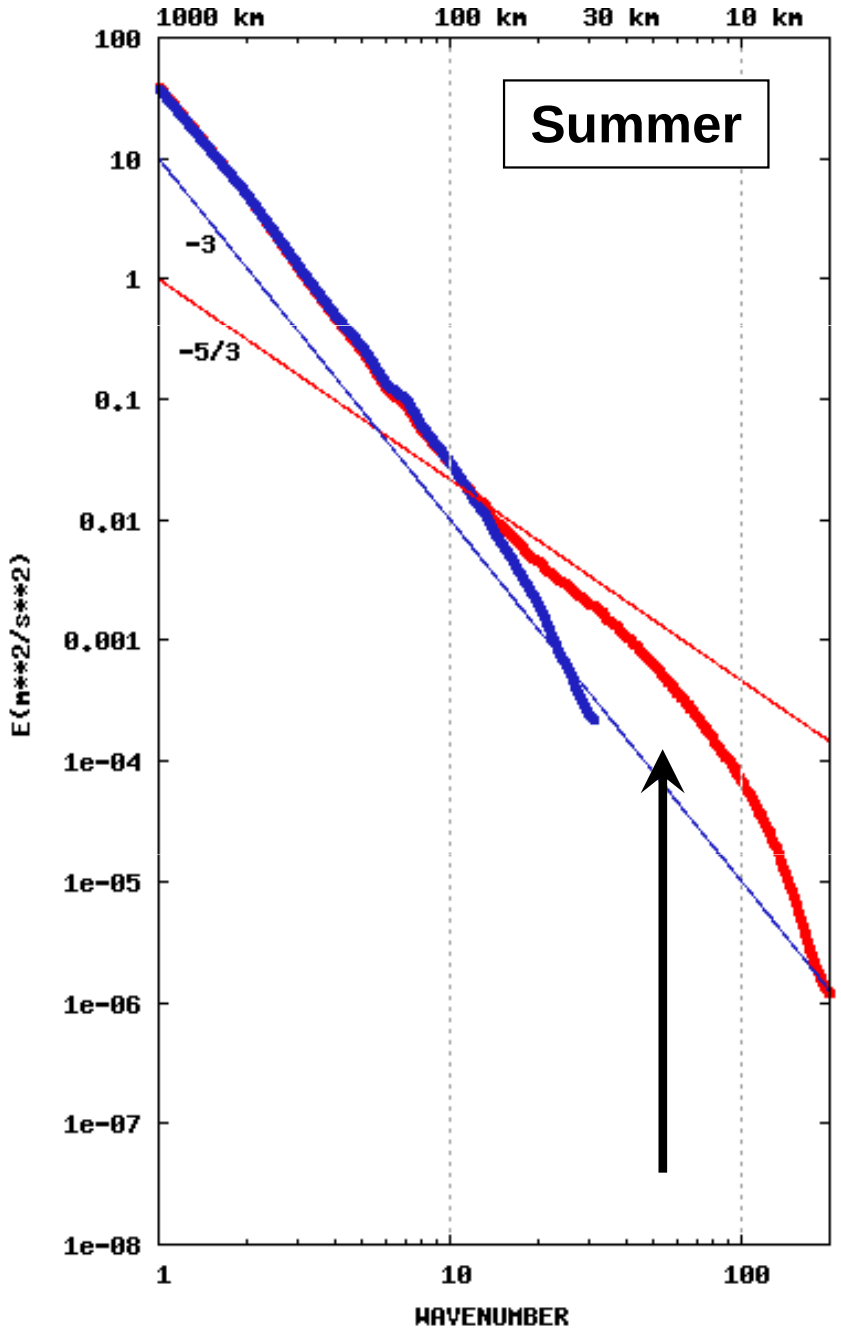
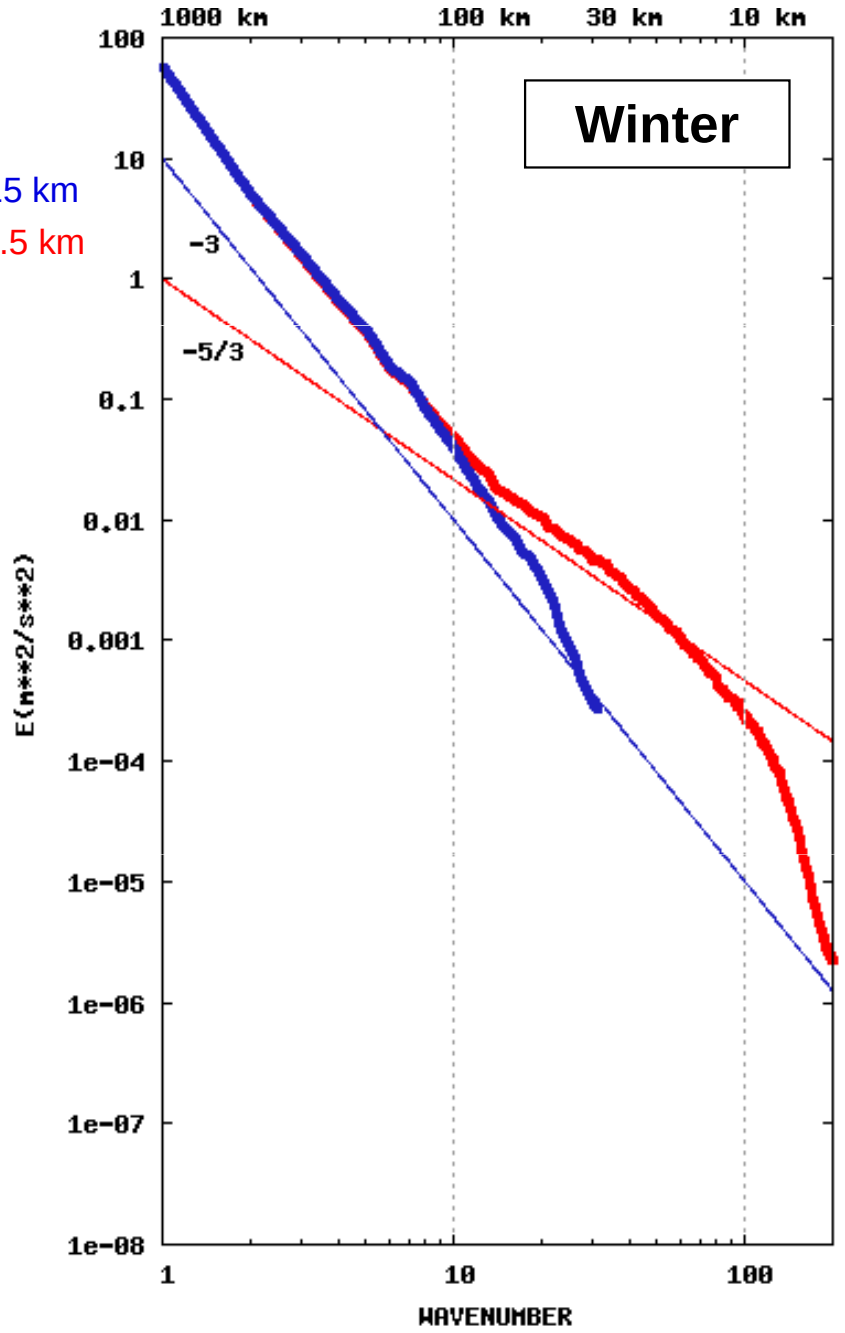


15Z

GEM-REG 15 km

GEM-LAM 2.5 km



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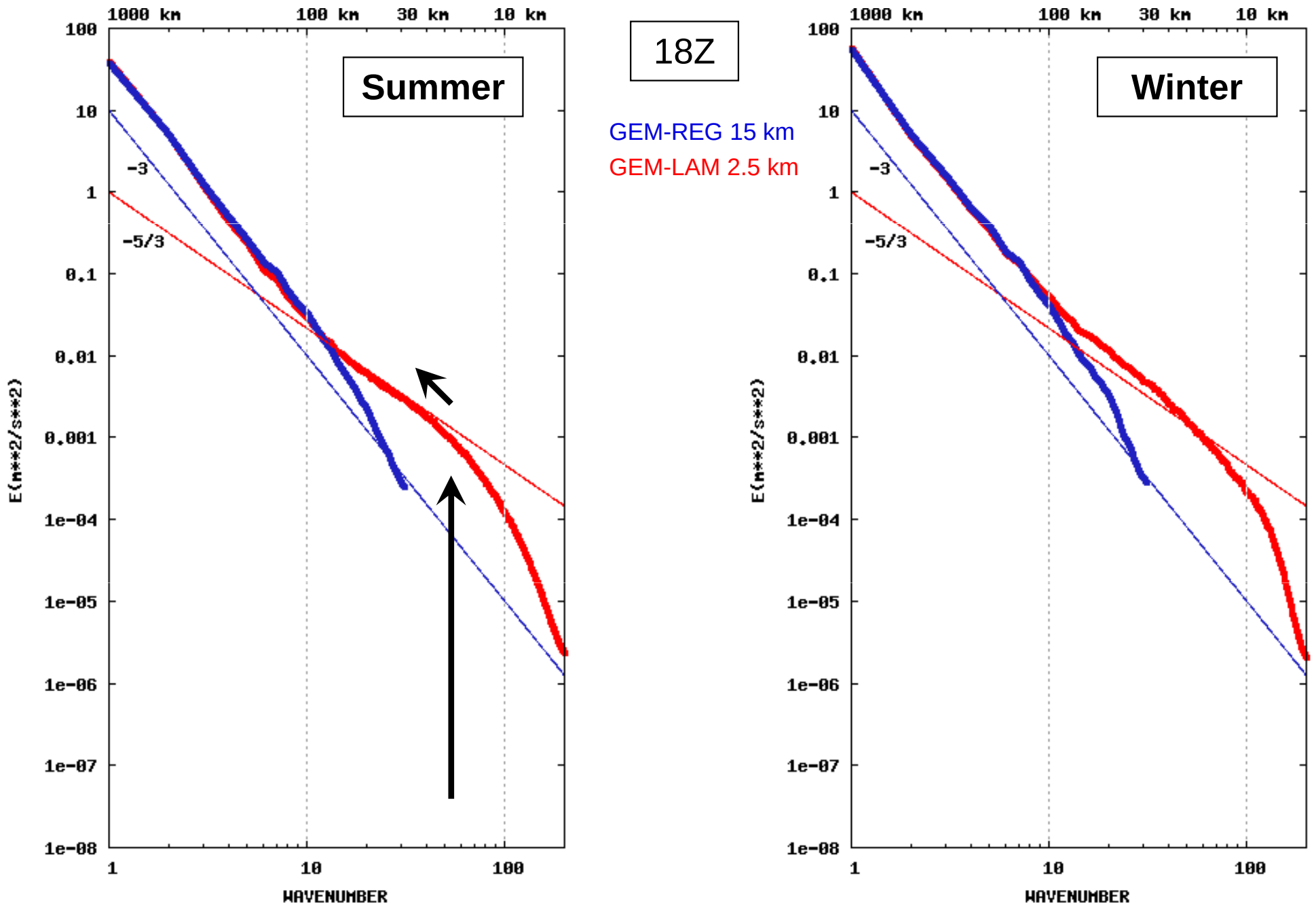

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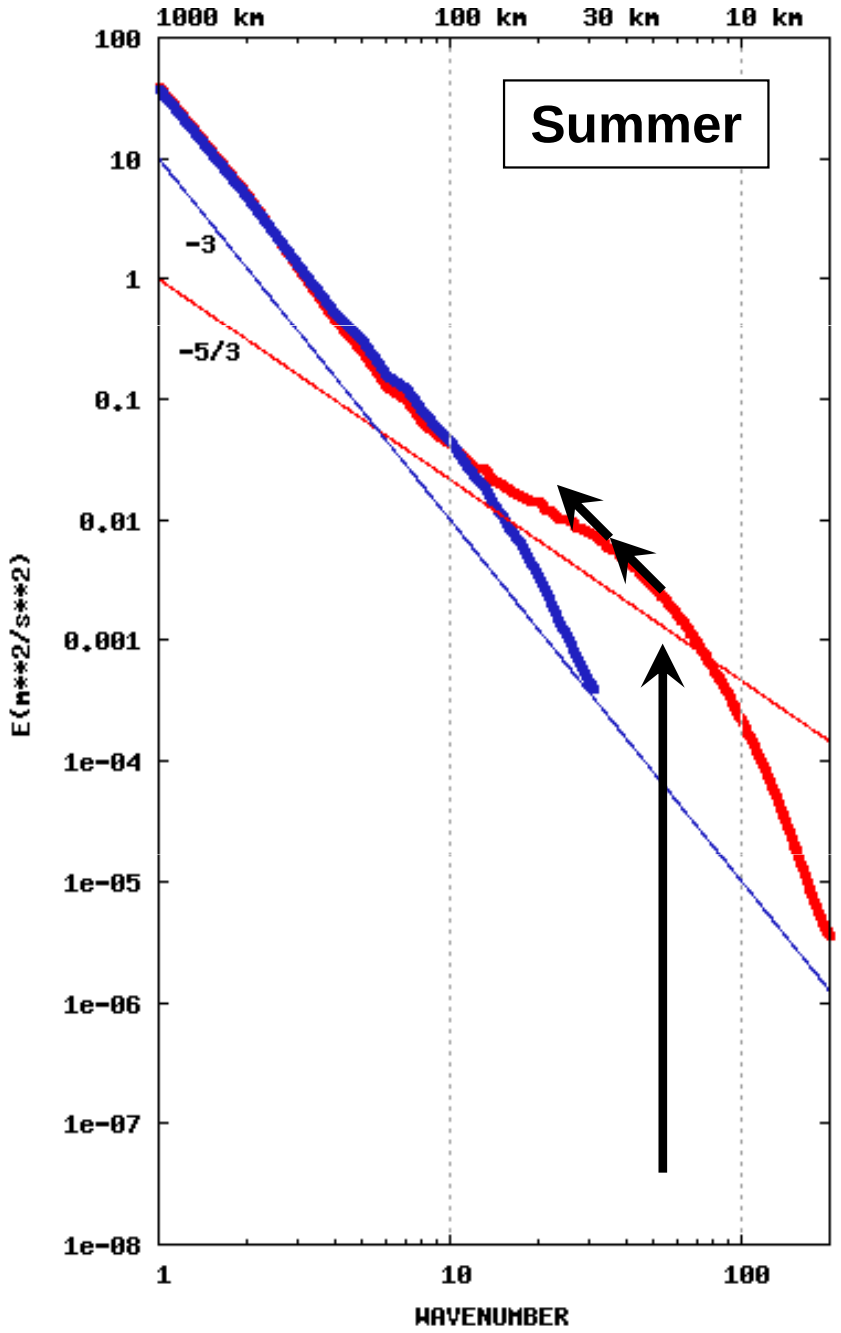

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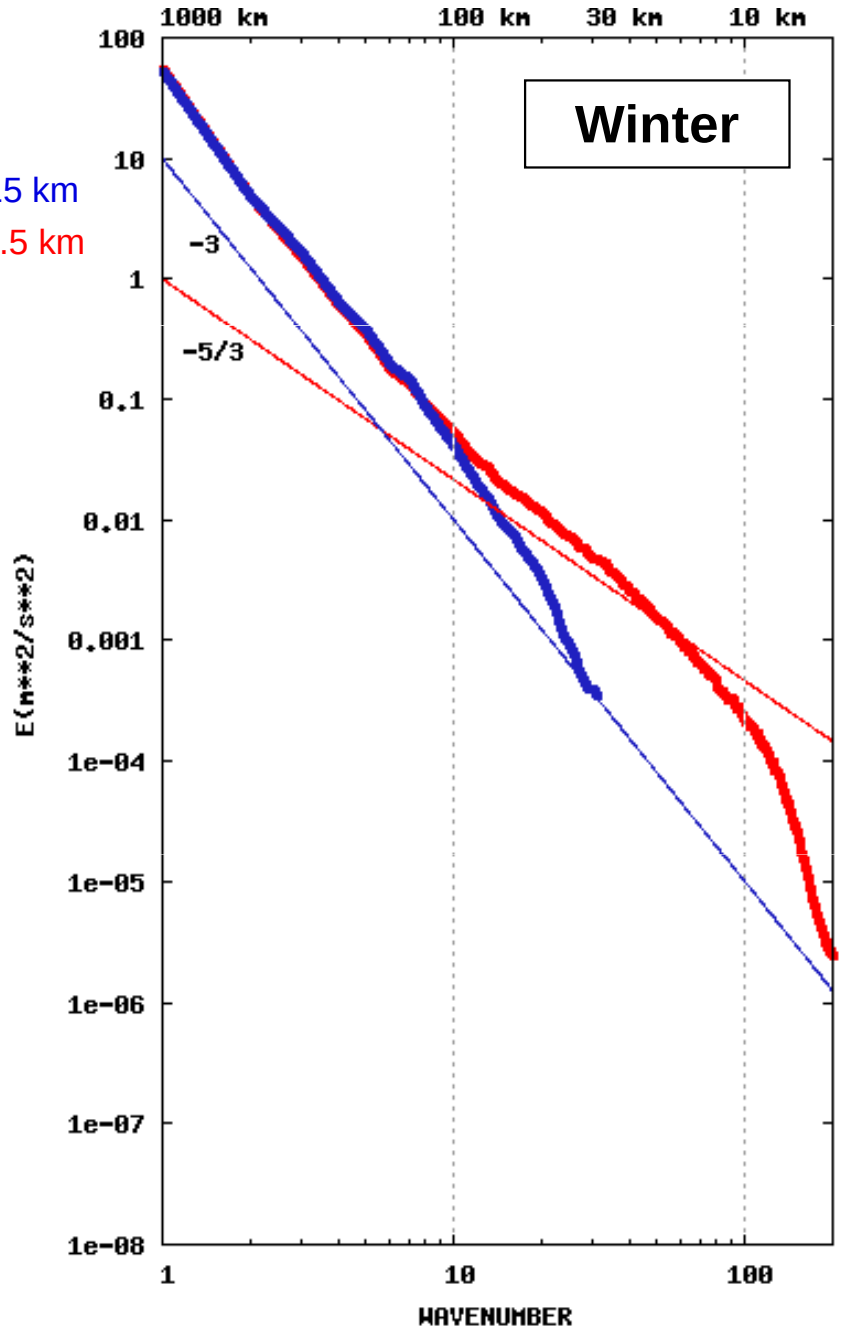

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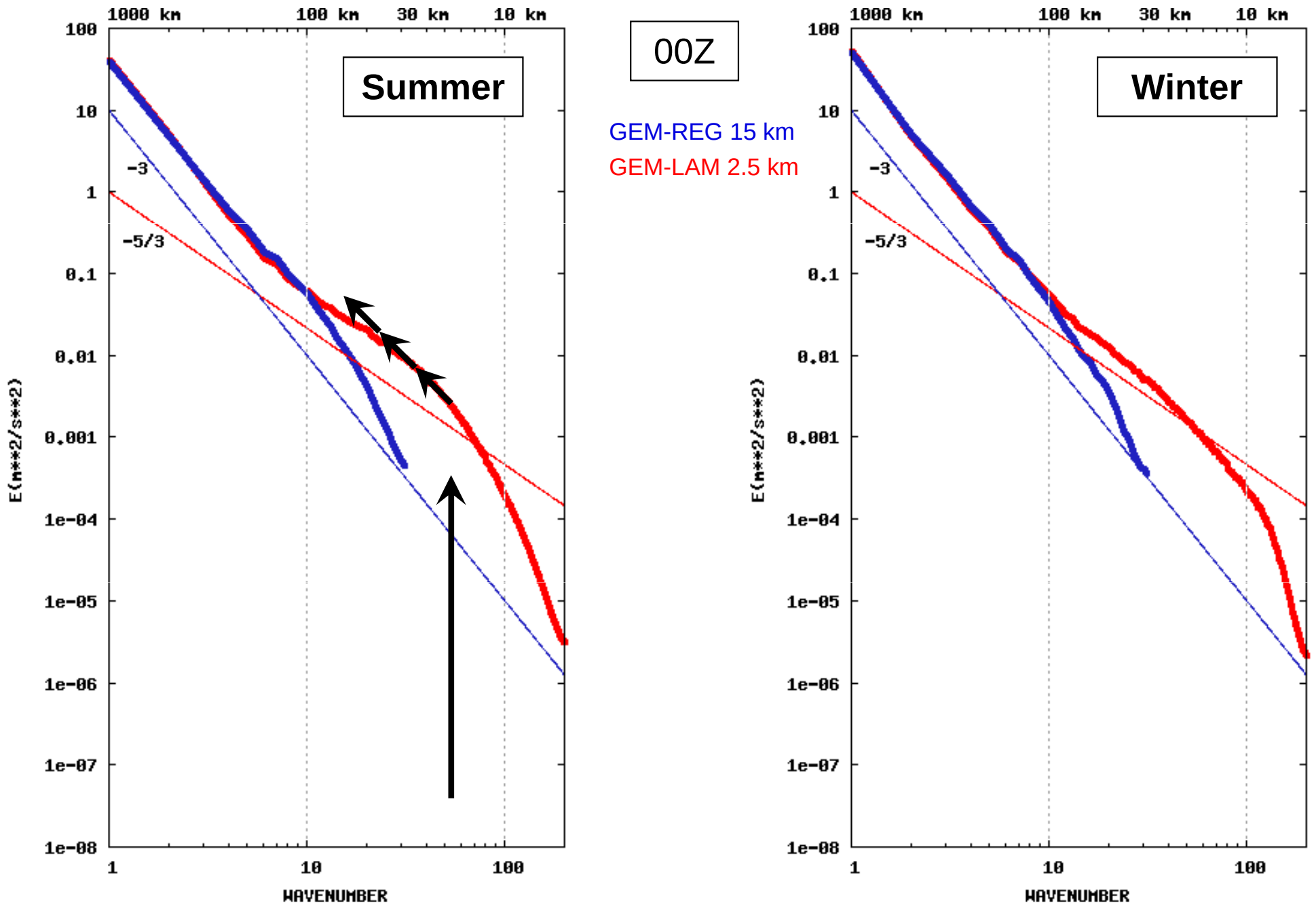
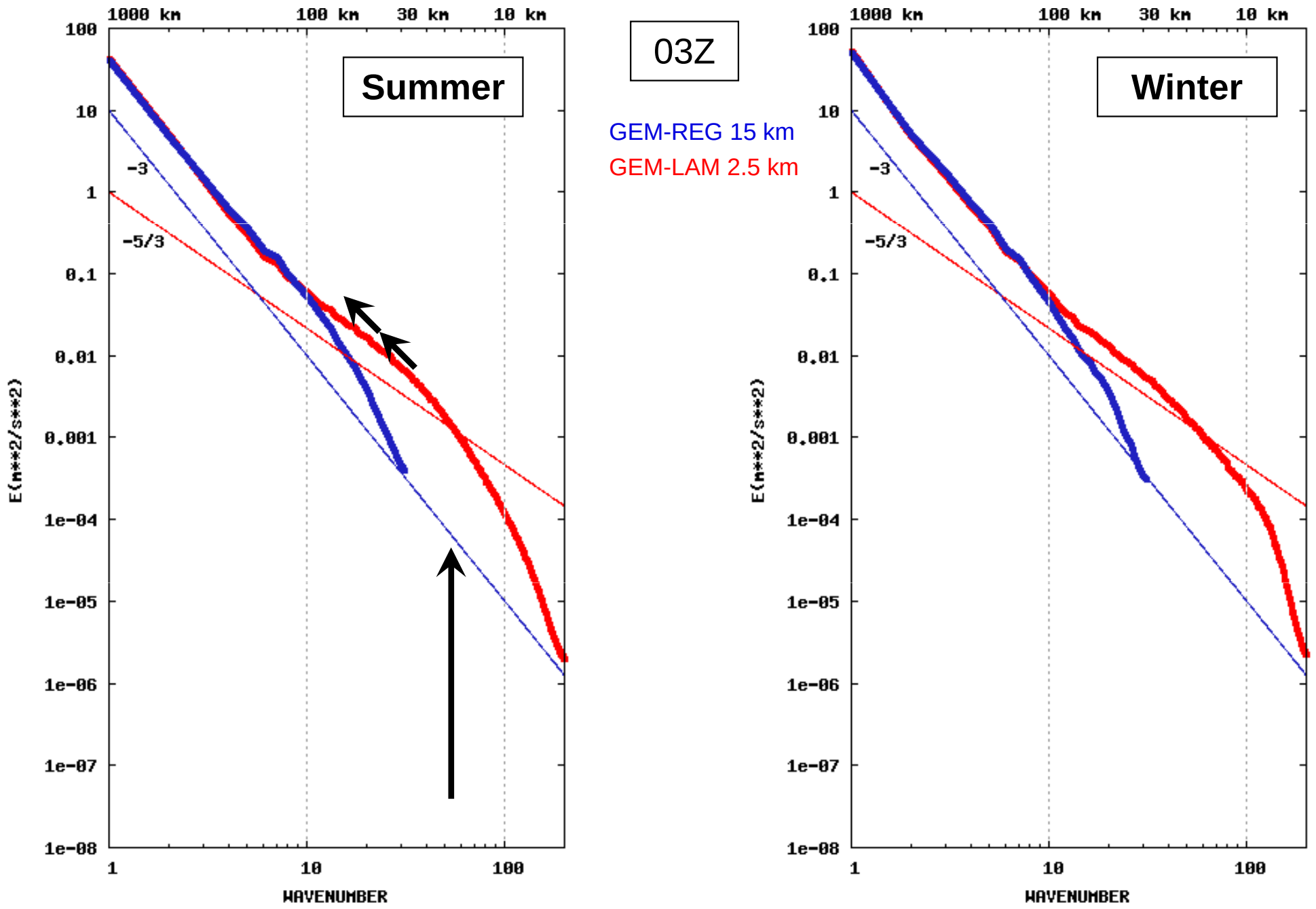


Results: diurnal cycle (bis)



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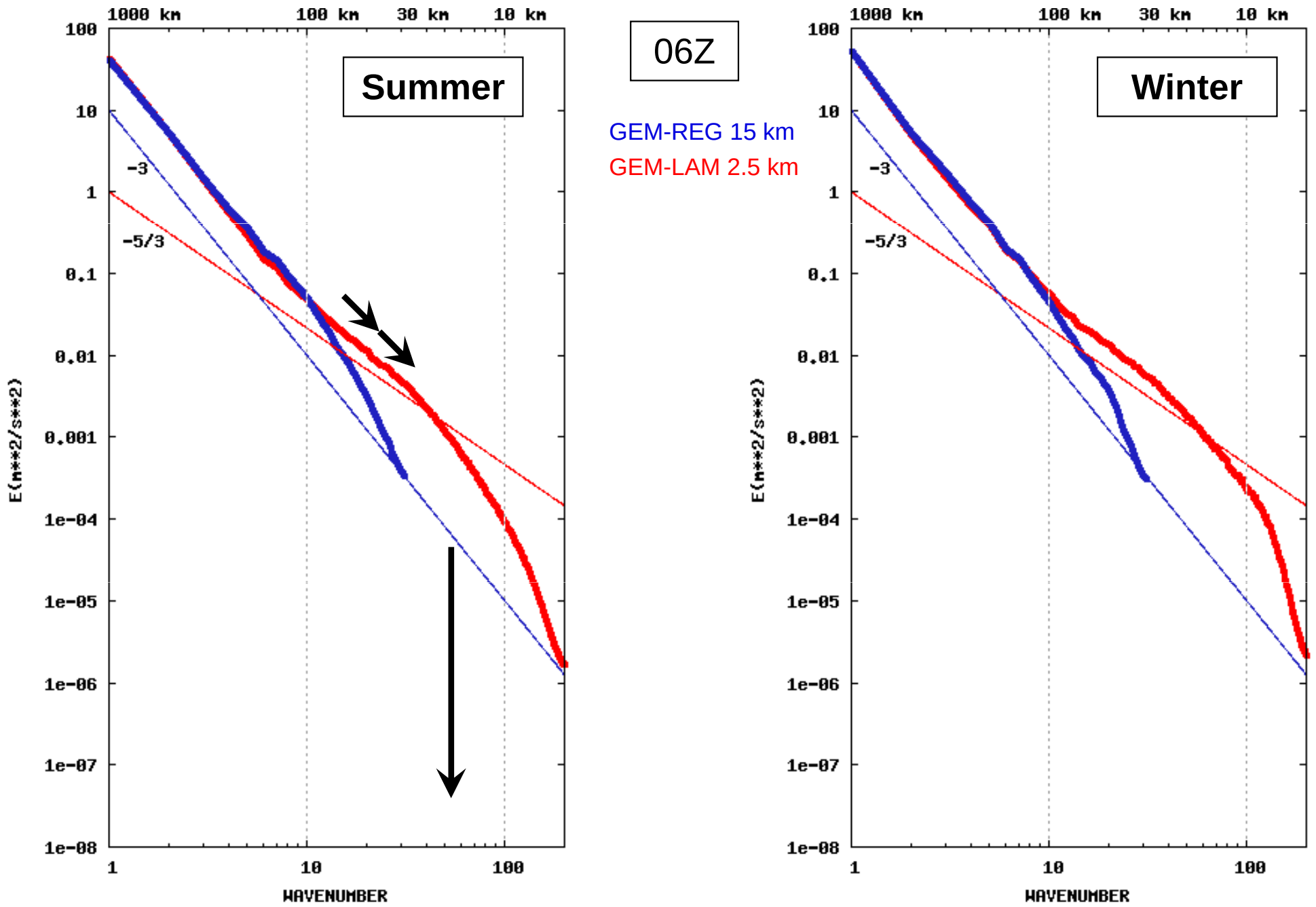

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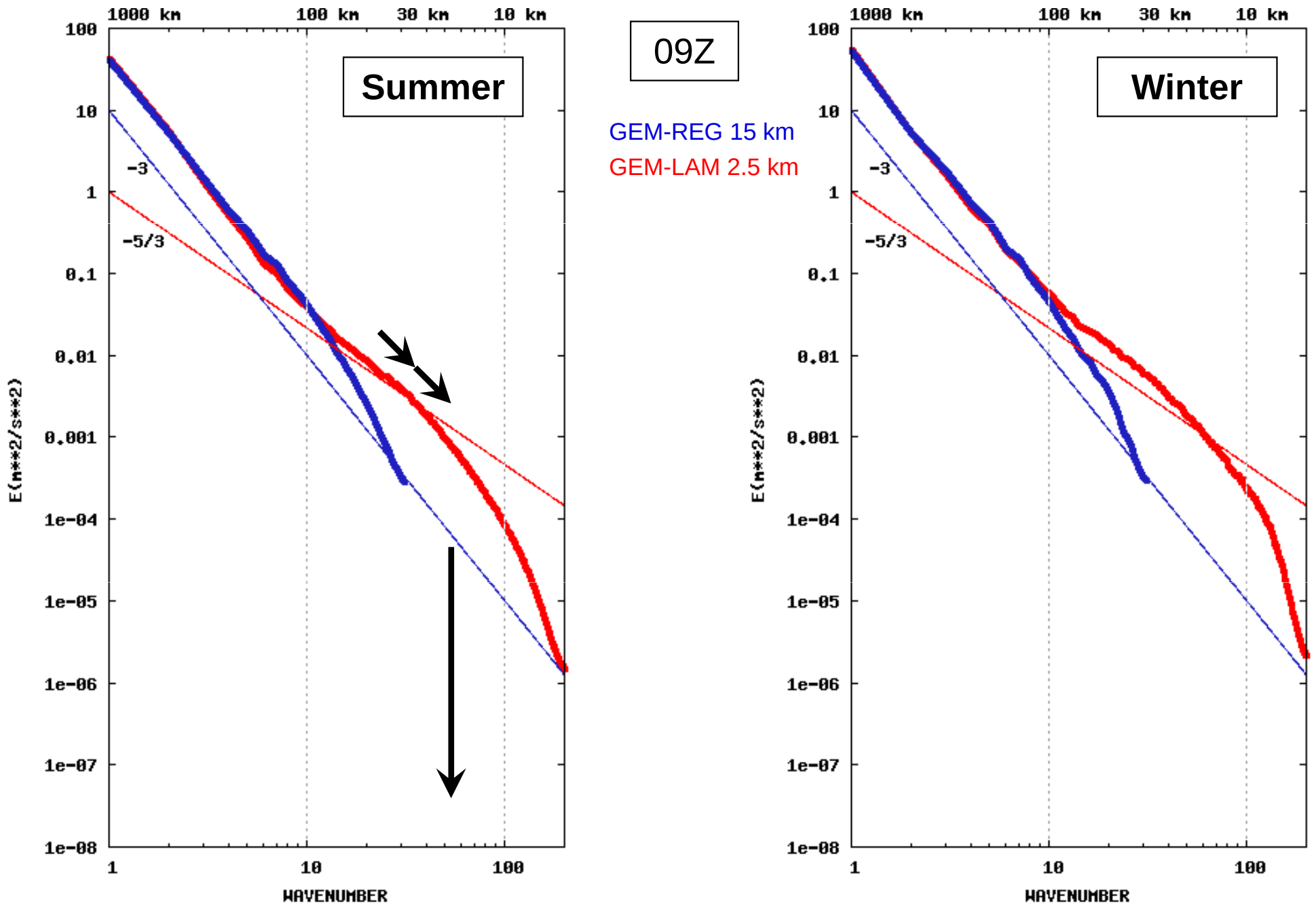

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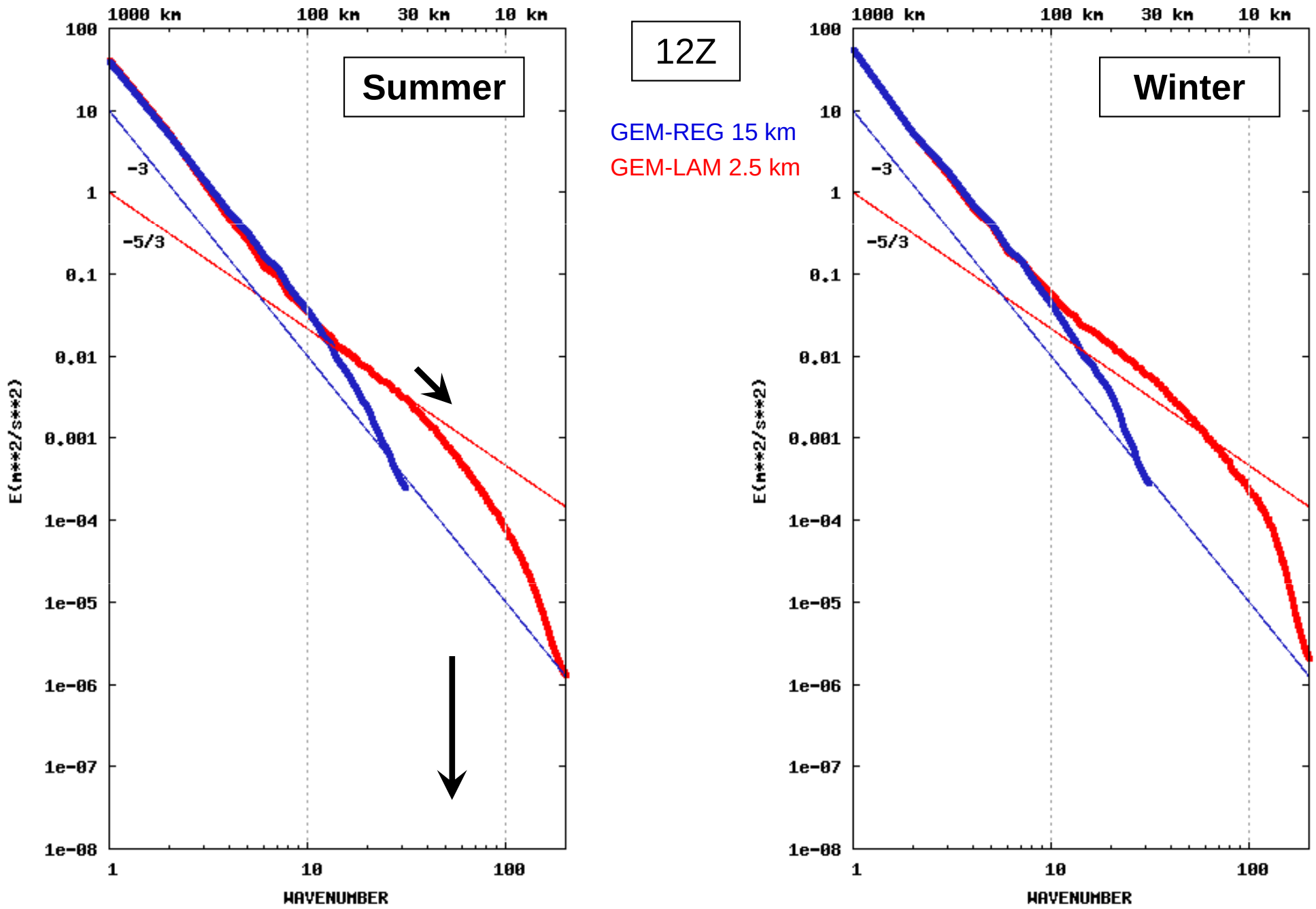

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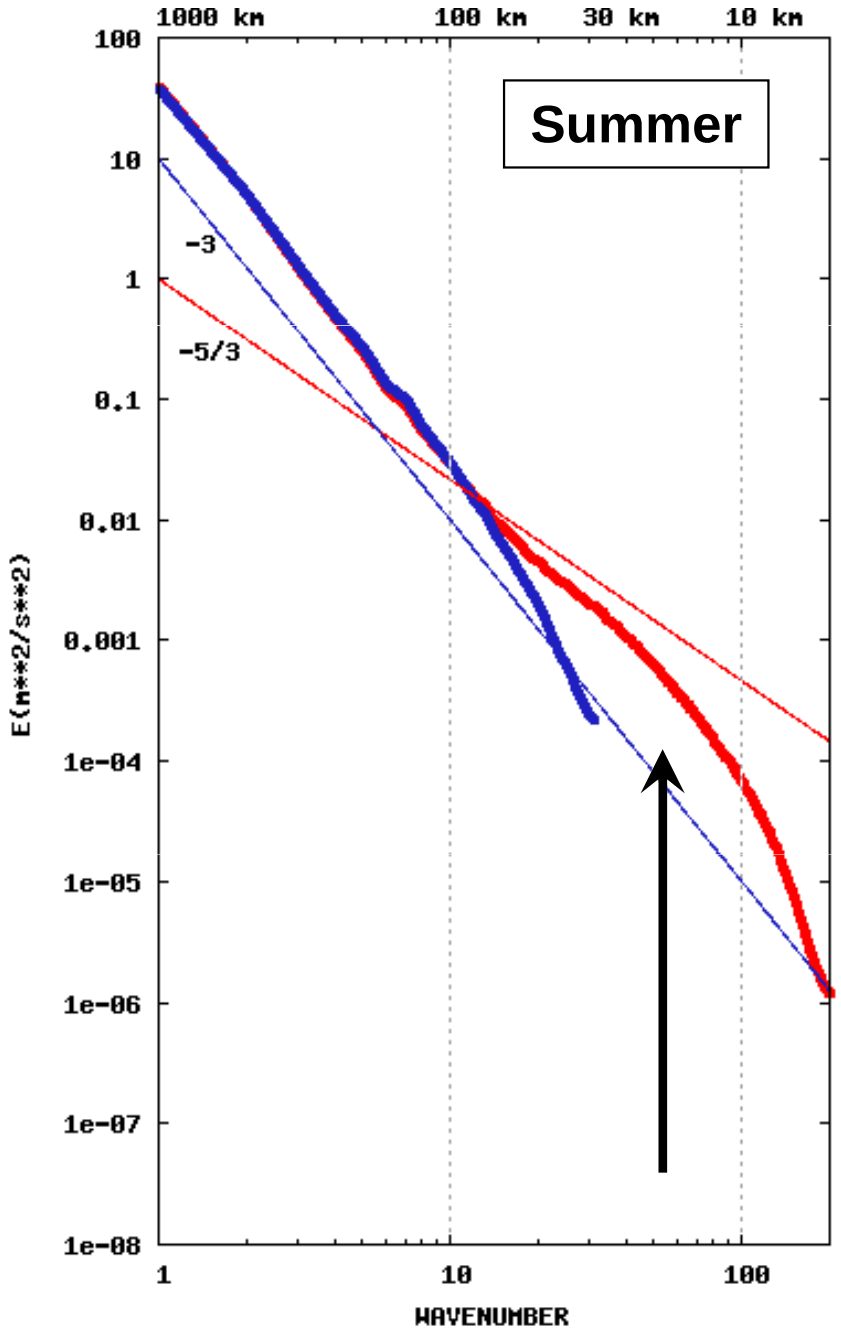

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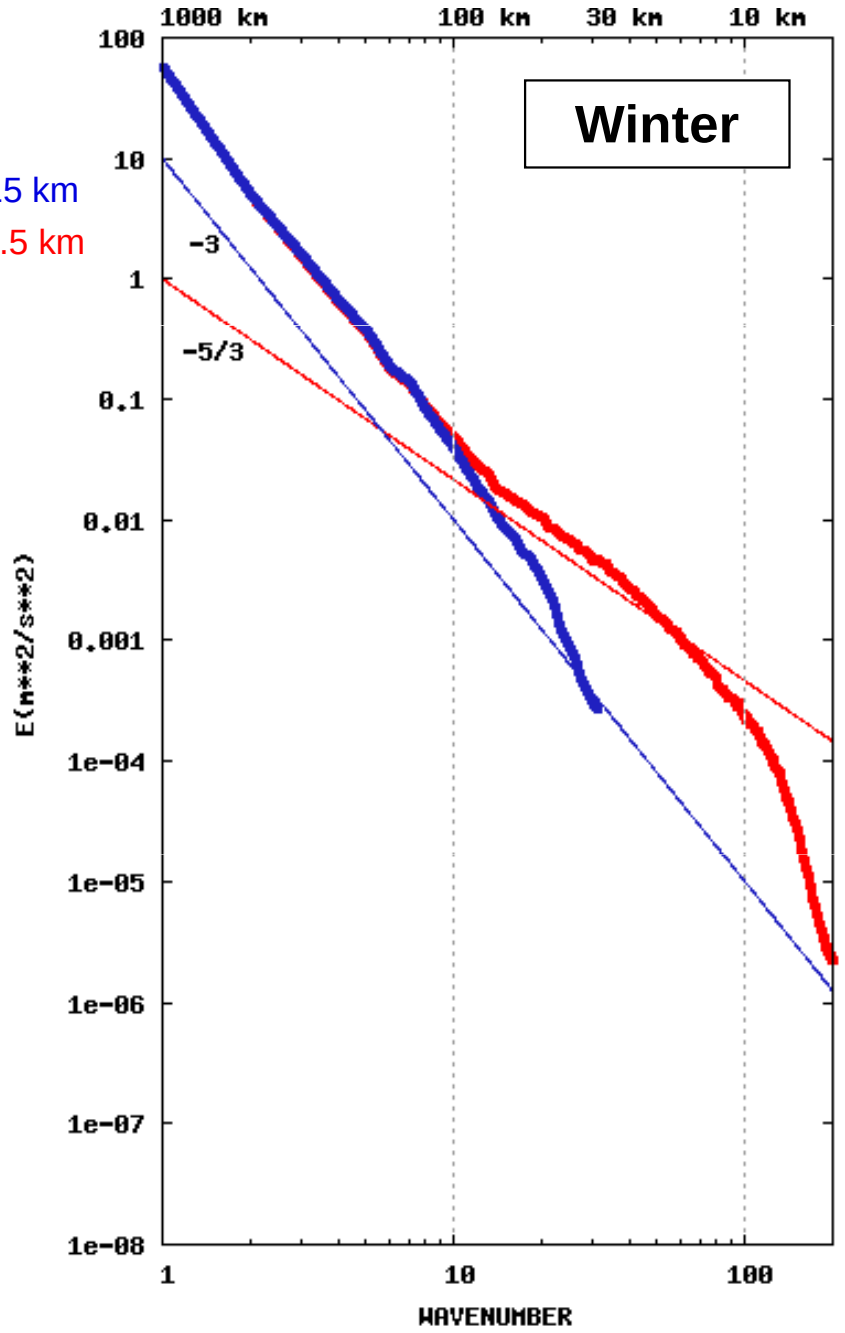
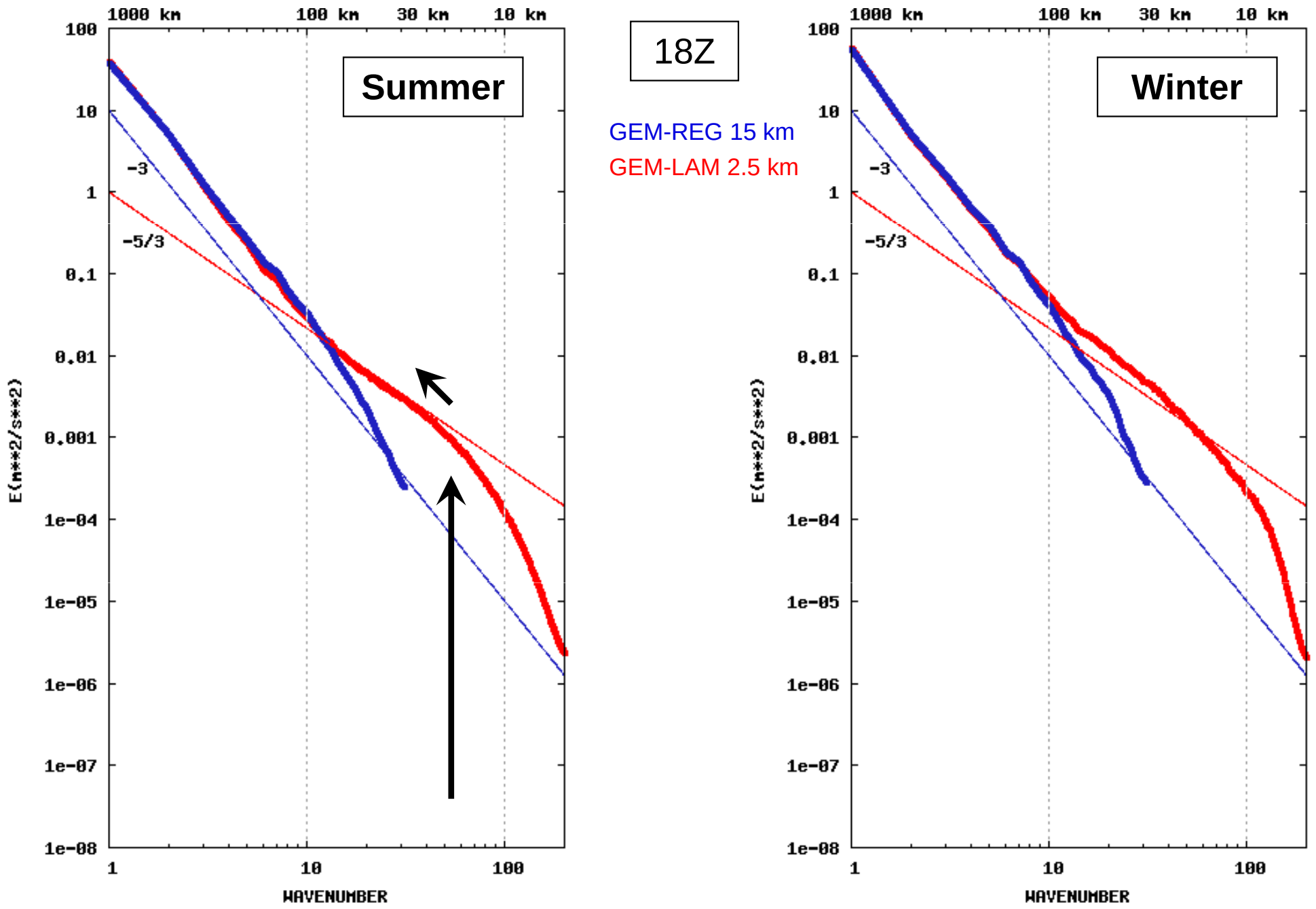
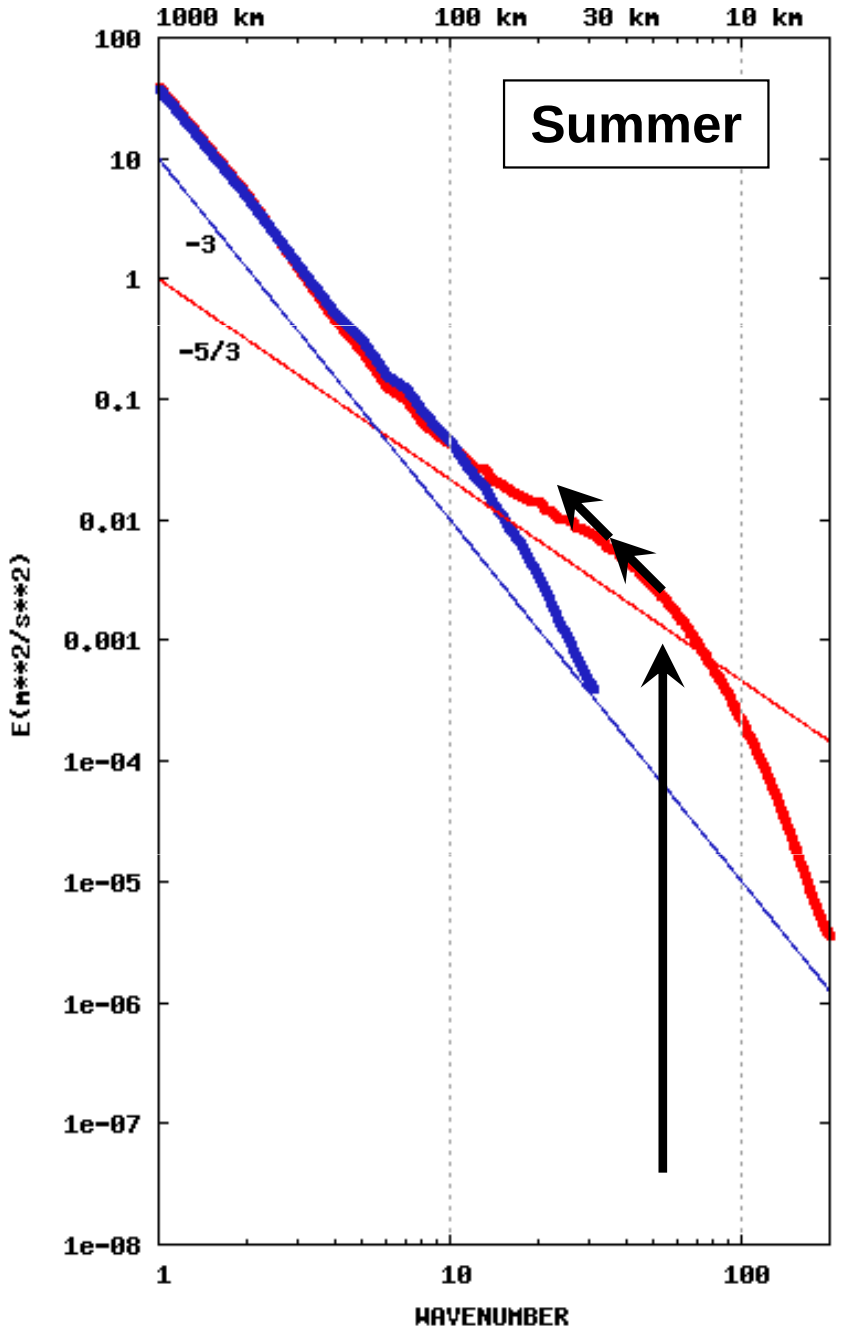


Results: diurnal cycle (bis)



Results: diurnal cycle (bis)



21Z

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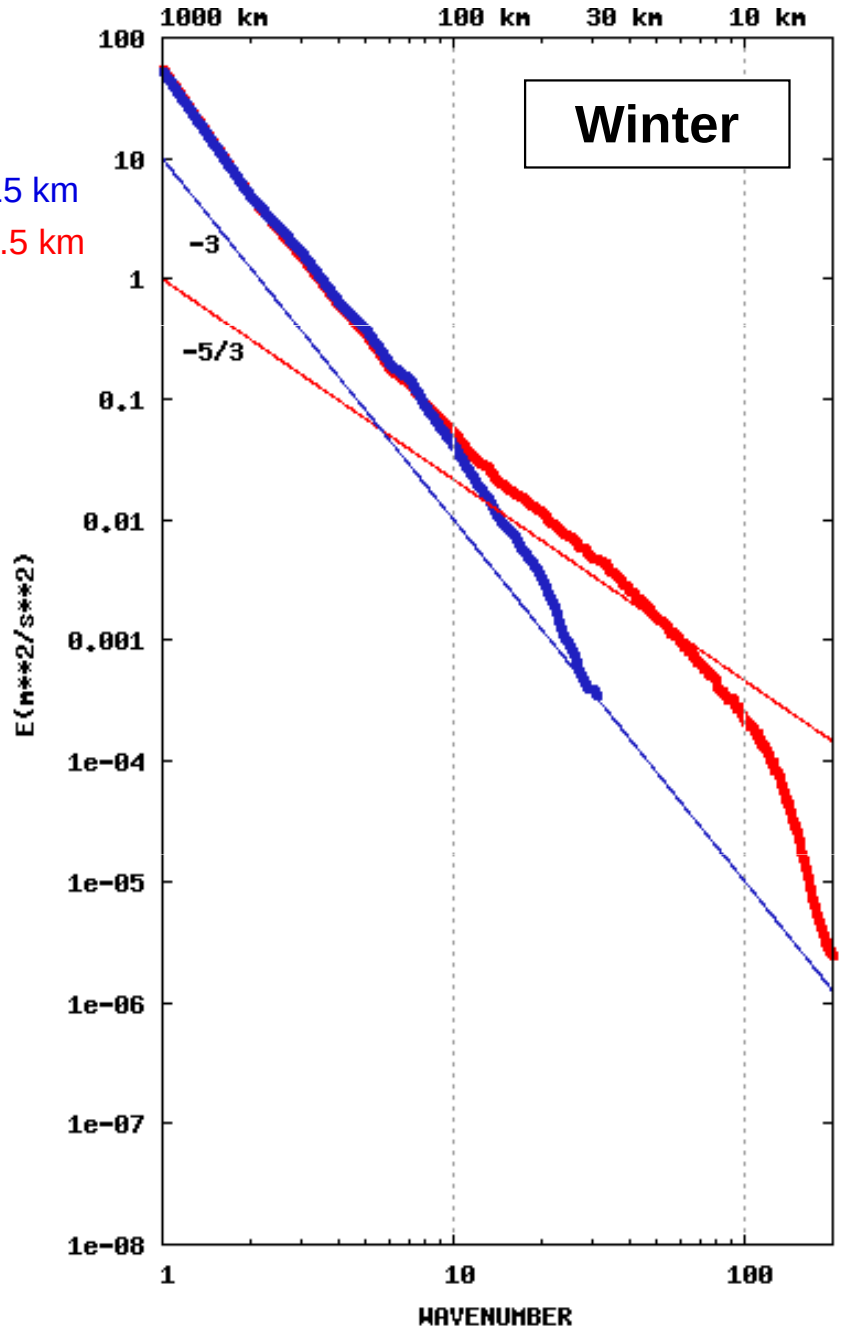
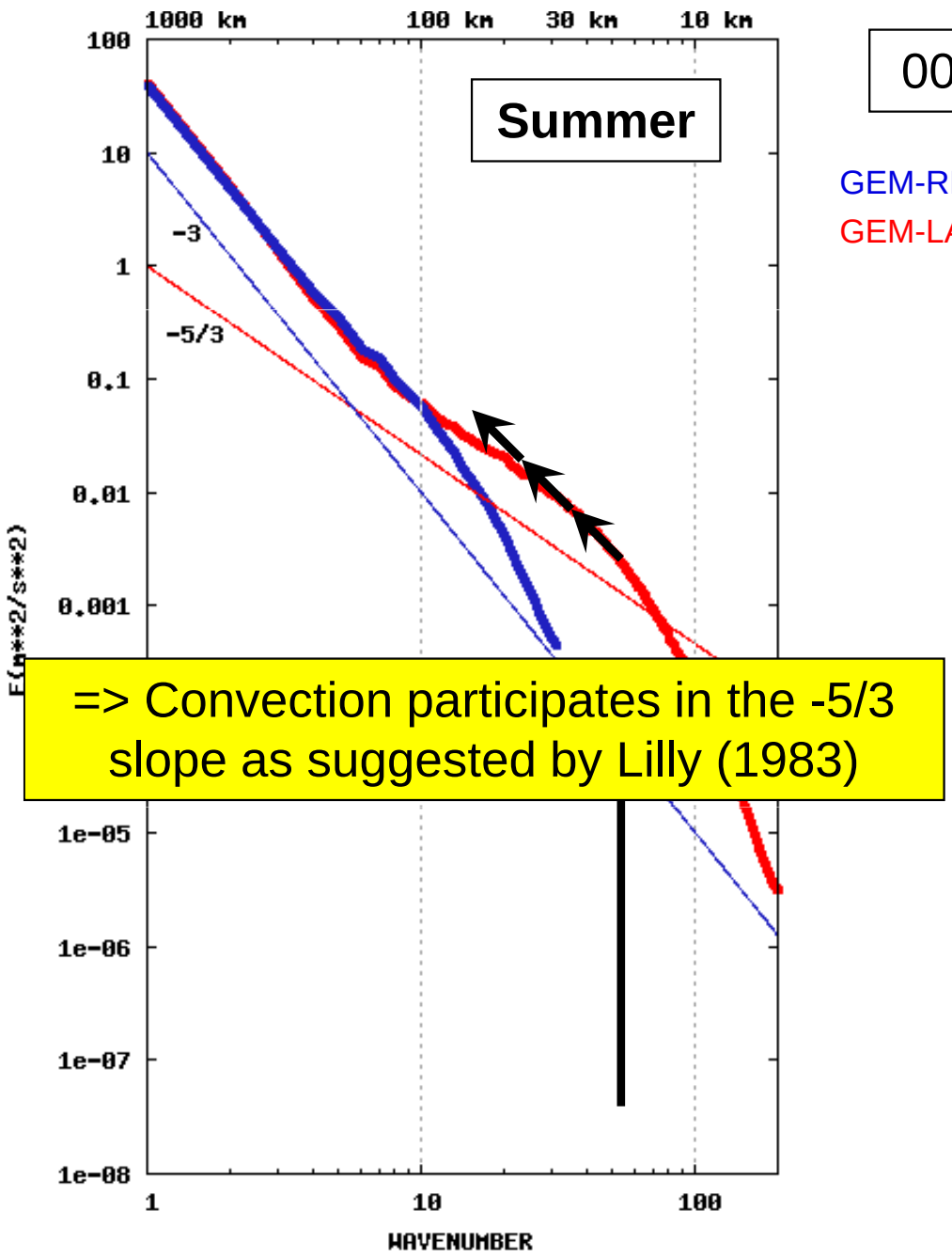


Results: diurnal cycle (bis)

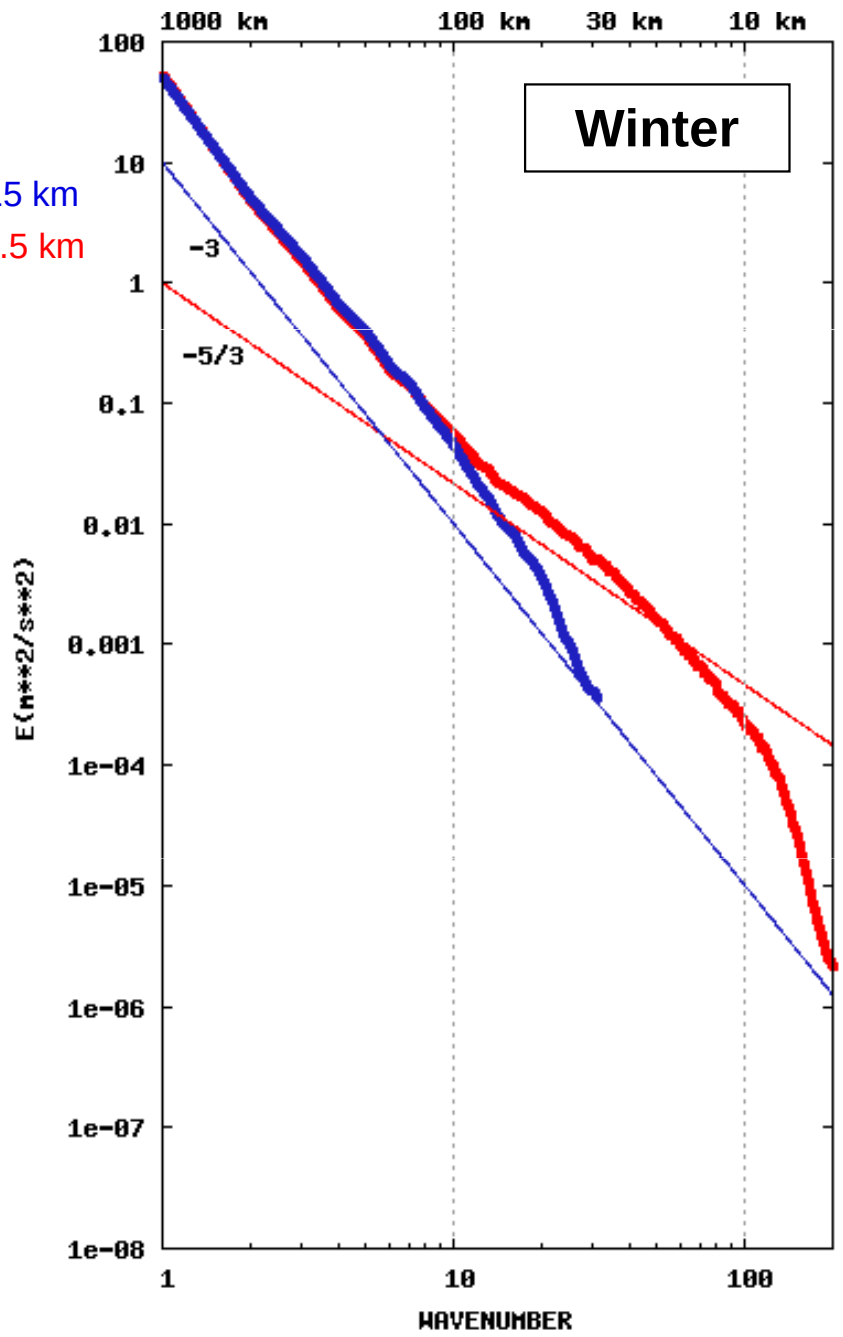


00Z

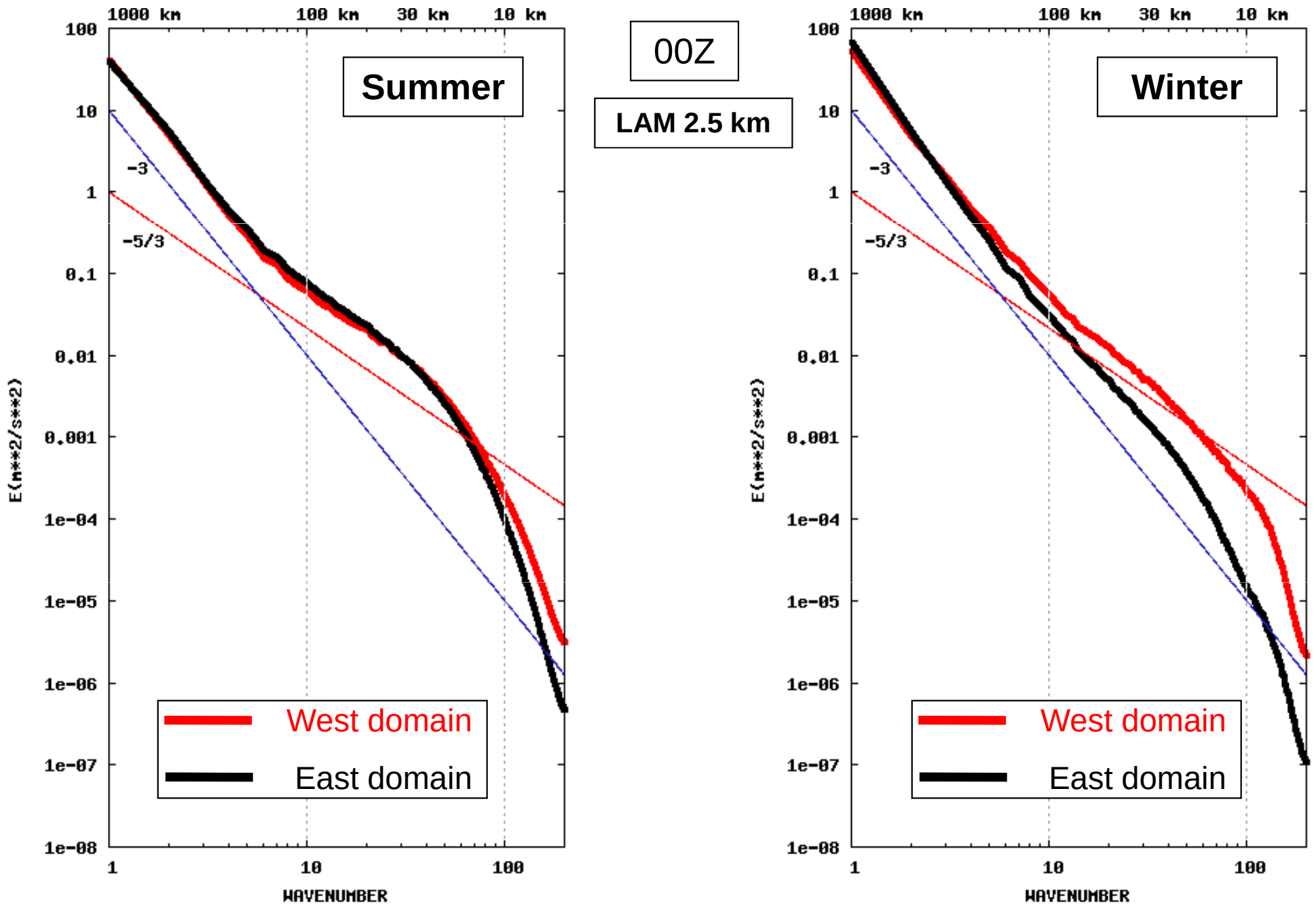
GEM-REG 15 km

GEM-LAM 2.5 km

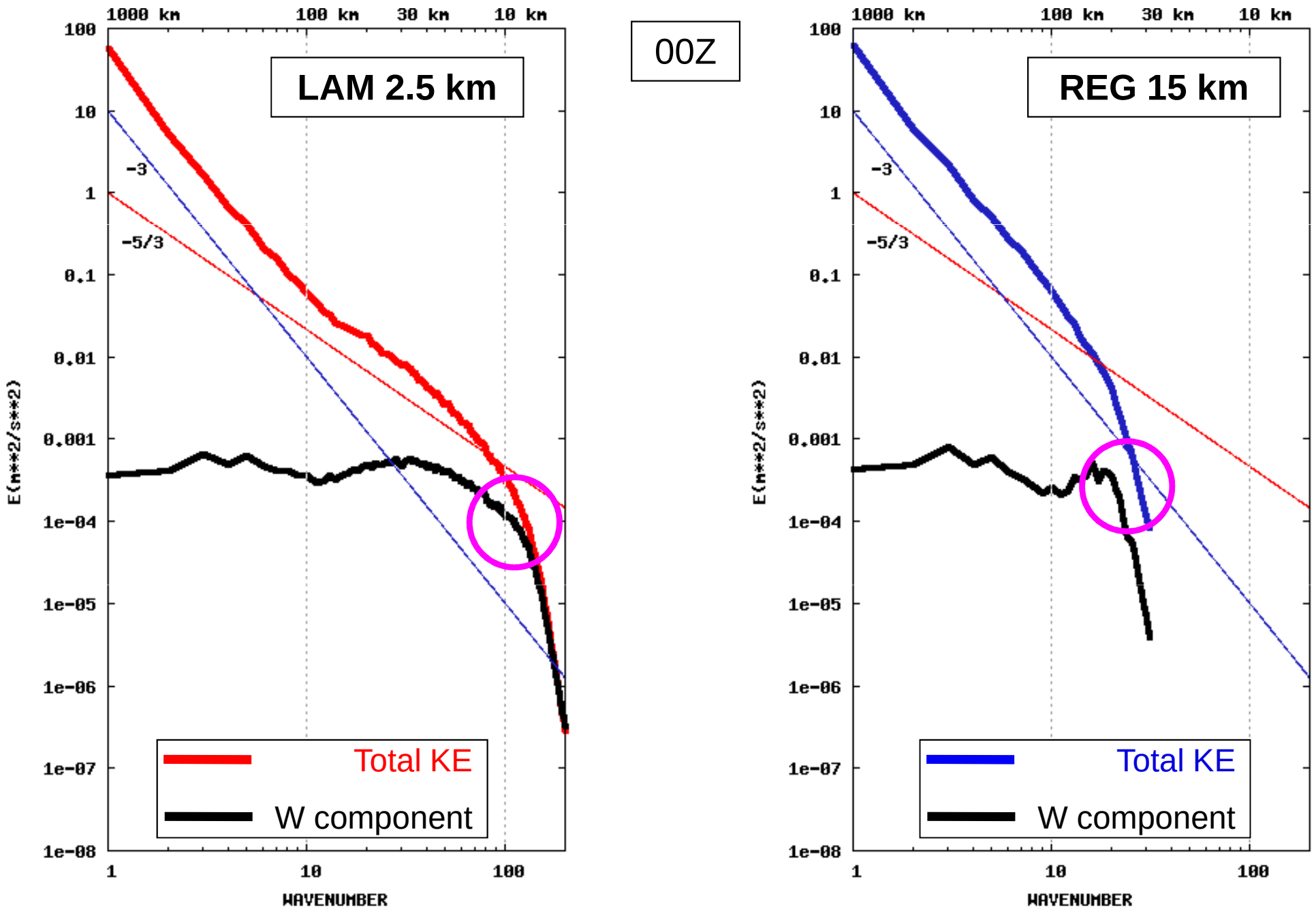
=> Convection participates in the -5/3 slope as suggested by Lilly (1983)



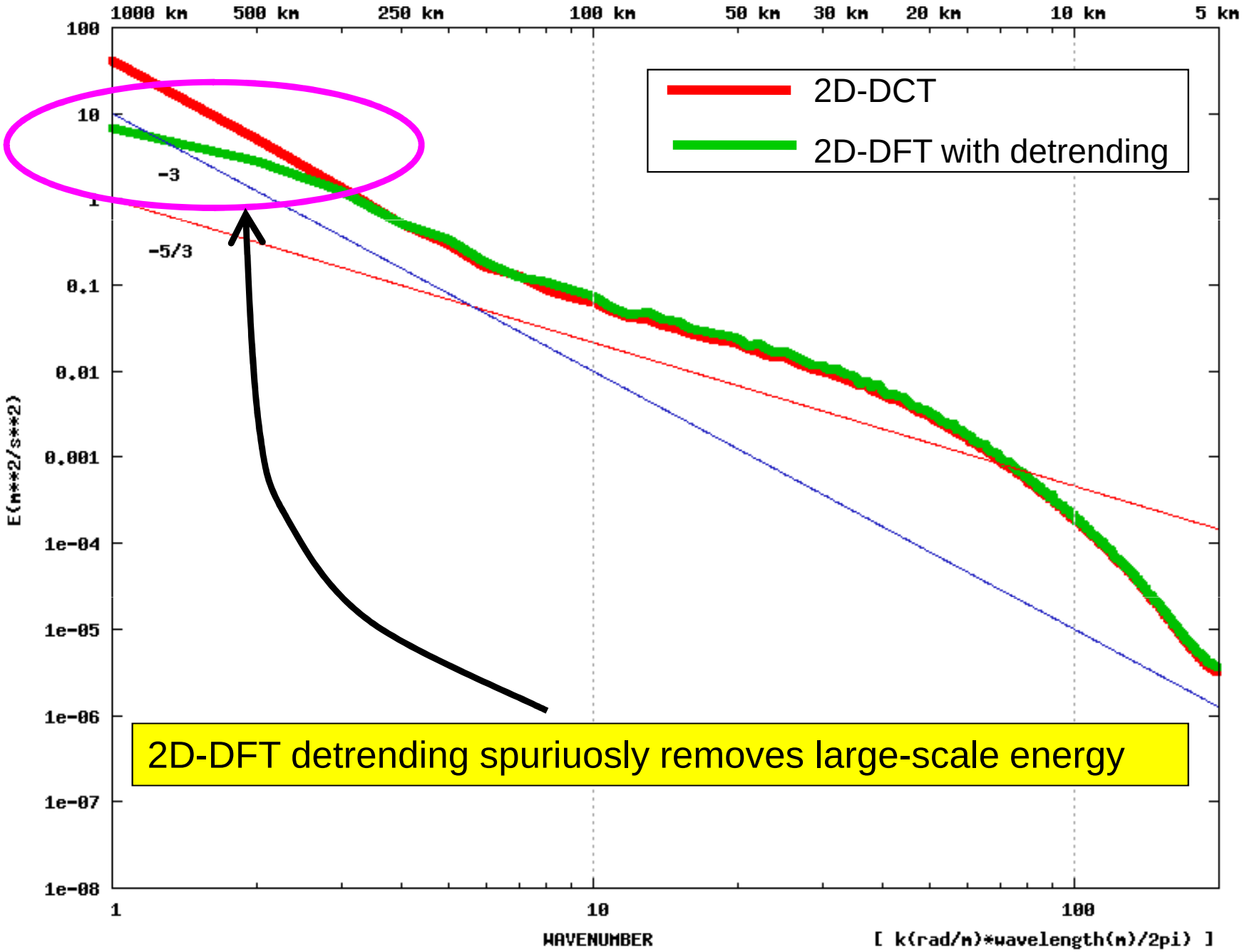
Results: Domain and seasonal impacts



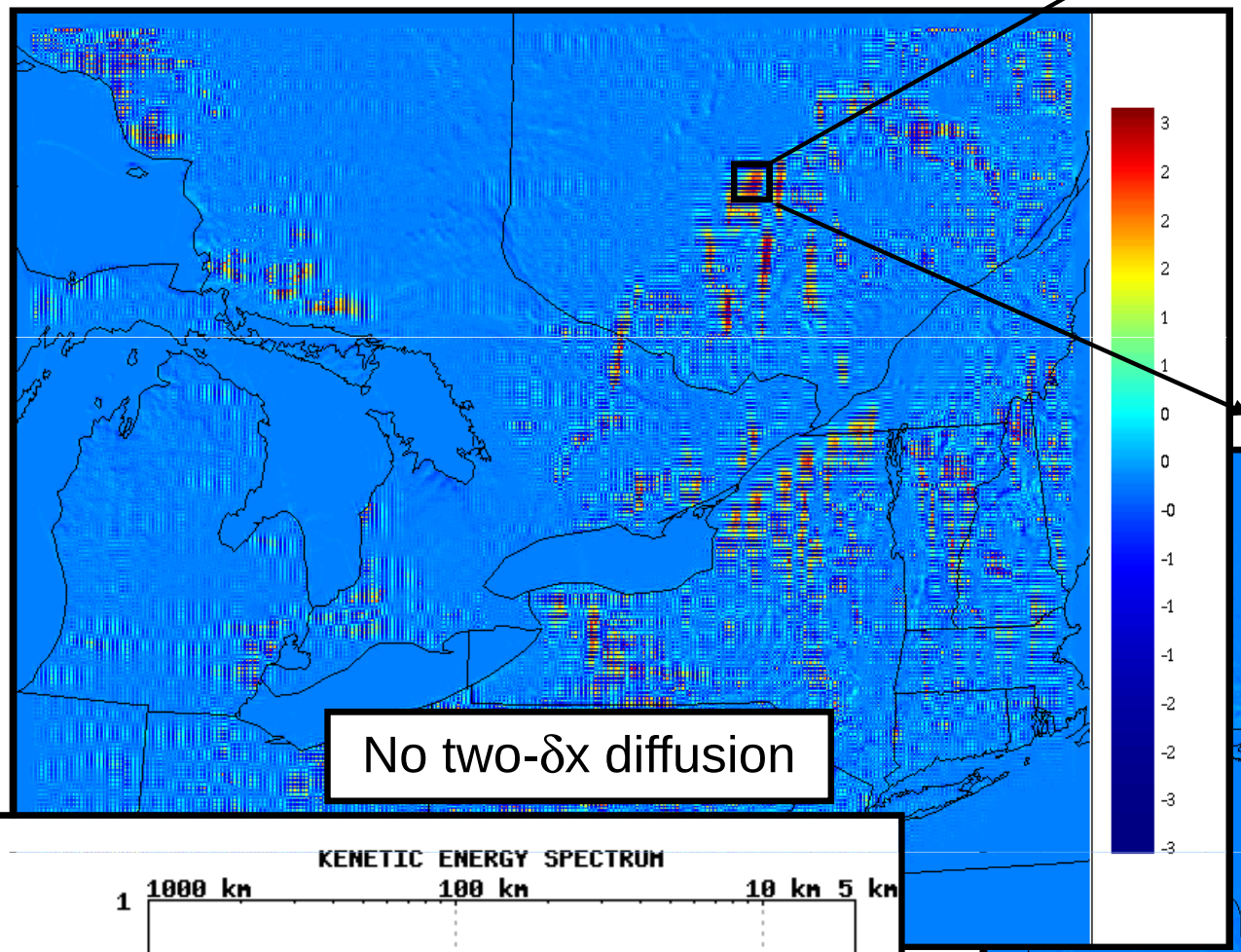
Results: W component vs total KE

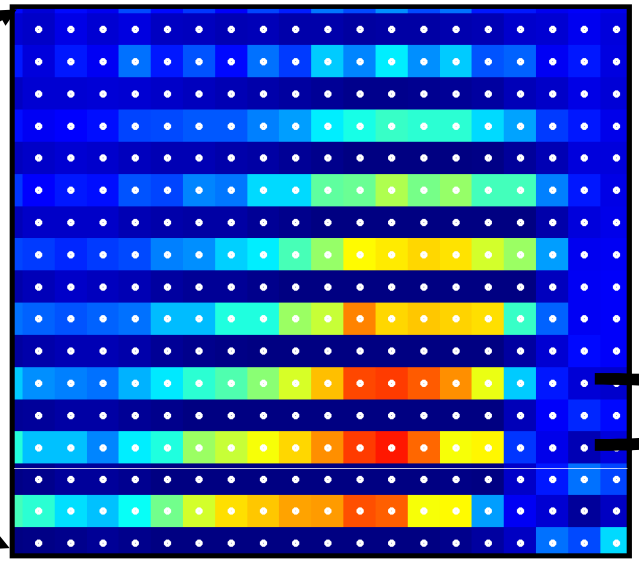


Results: 2D-DCT vs 2D-DFT with detrending



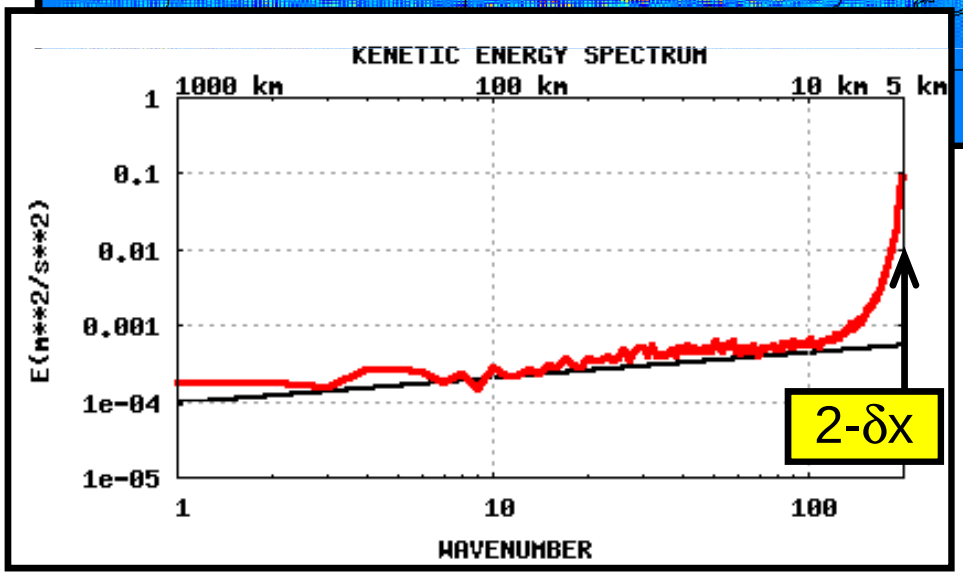
Vertical motion (m/s) at model level 0.995

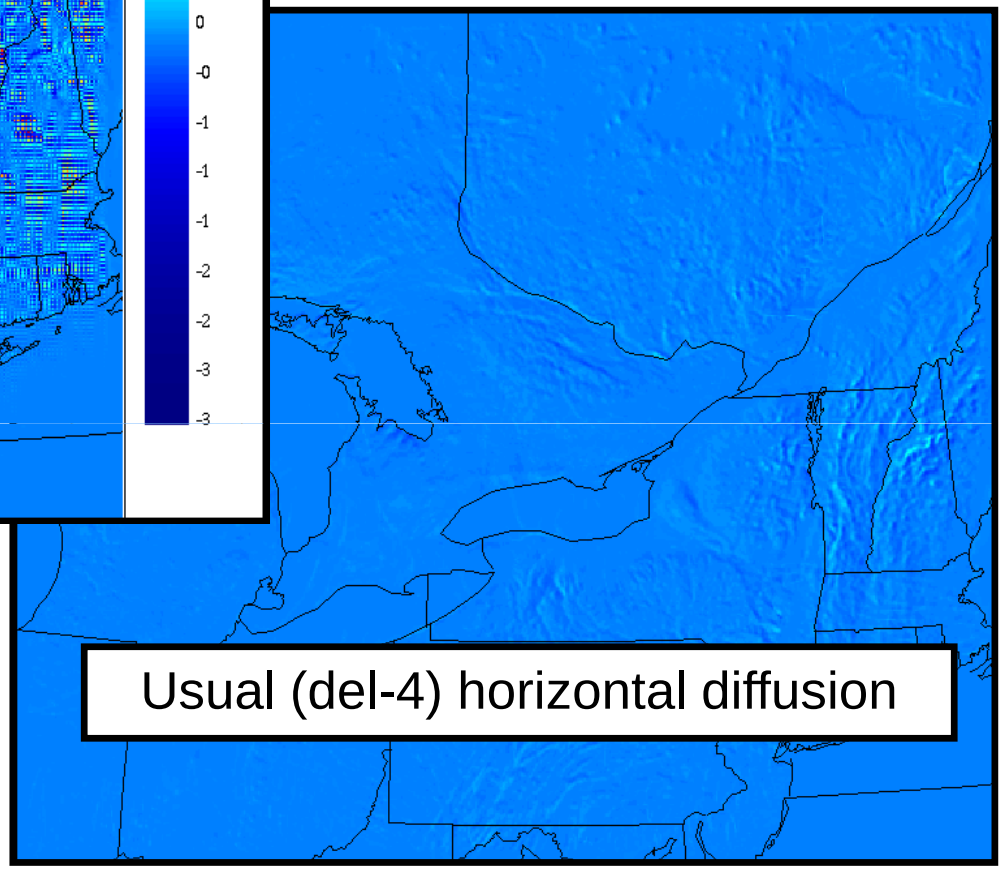




2δx

No two-δx diffusion





Usual (del-4) horizontal diffusion

Conclusions

- **-5/3 spectral dependency and transition**
  - Generated by the LAM 2.5 km, not by the REG 15 km
- **Effective resolution**
  - LAM 2.5 km : ~17 km
  - REG 15 km : ~105 km
- **Spin-up time of LAM 2.5 km small scales**
  - ~ 3h
- **Diurnal cycle**
  - Convectively driven (summer)
  - Participates in the – 5/3 slope as Lilly (1983) suggested
- **Influence of the domain (geophysical forcing)**
  - No major impact during summer conditions
  - West domain exhibits higher level of small-scale energy in winter
- **Vertical velocity energy vs total KE**
  - LAM 2.5 km near to 3D turbulence at scales < 10 km
  - REG 15 km never close to 3D turbulence

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Thank you!