UCL-UM Up

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1. ExUM and Radar data trends
2. Tidal analysis
3. Next steps

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1. Data Tre

3

Data

ExUM

Radar

4

Data

ExUM

- 1D-CIRA
- 3D-CIRA
- DTM

Radar

4.1

Data

ExUM

- 1D-CIRA
- 3D-CIRA
- DTM

Radar

- Ascension
- Esrange
- Rothera

4.2

Data

ExUM

3-hourly

- 1D-CIRA
- 3D-CIRA
- DTM

Radar

hourly

- Ascension
- Esrange
- Rothera

Data

ExUM

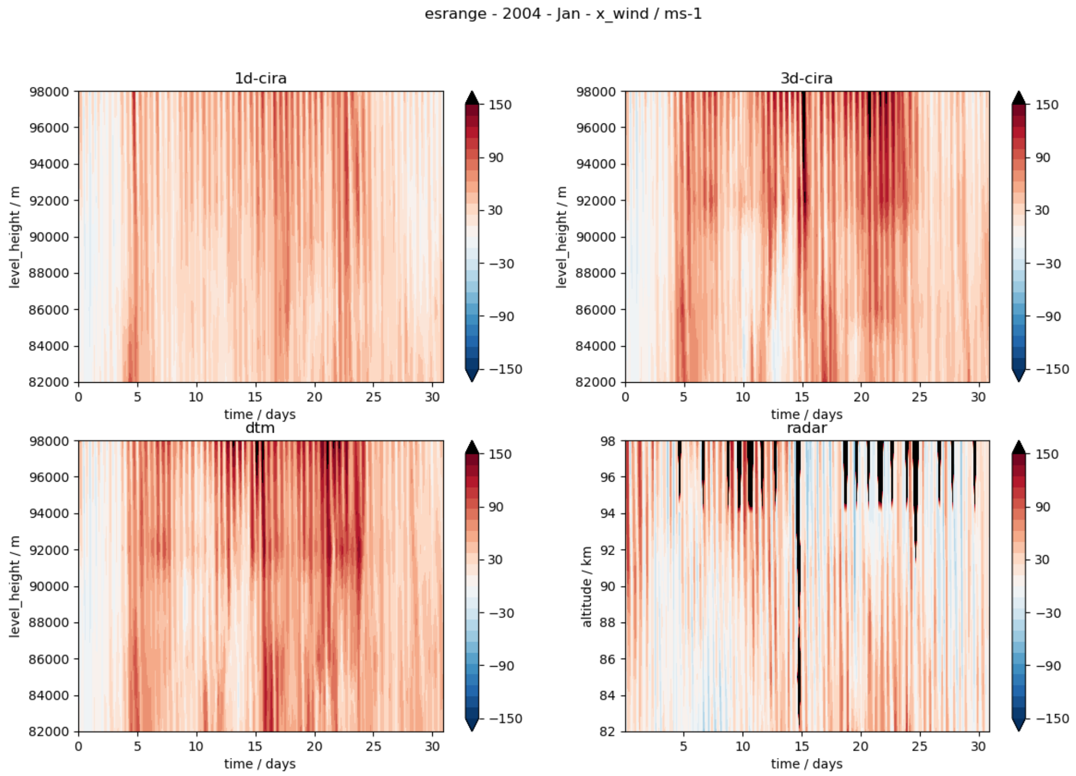
3-hourly

- 1D-CIRA
- 3D-CIRA
- DTM

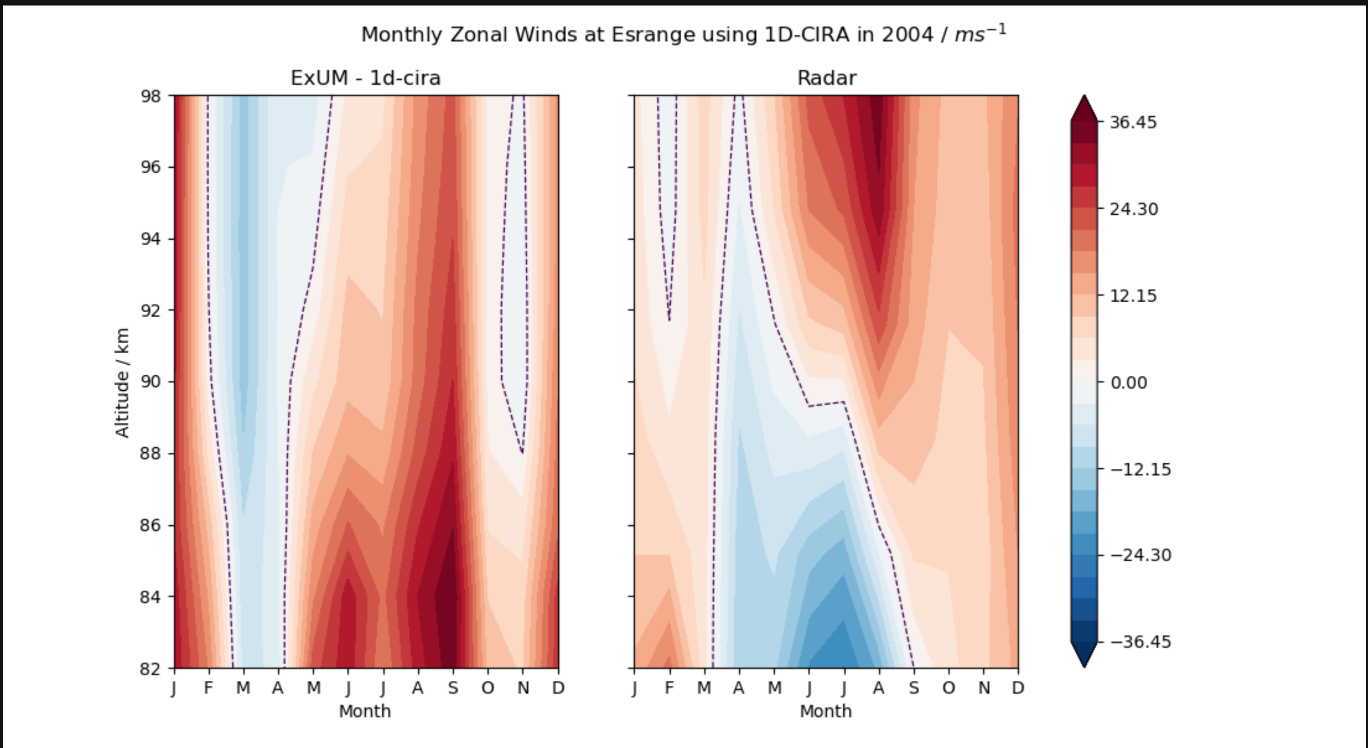
Radar

hourly

- Ascension
- Esrange
- Rothera


esrange - 2004 - Jan - x_wind / ms-1
1d-cira
3d-cira
dtm
radar
level_height / m
altitude / km
time / days
150
90
30
−30
−90
−150

6


Monthly Zonal Winds at Esrange using 1D-CIRA in 2004 / ms^{-1}
ExUM - 1d-cira
Radar
Altitude / km
98
96
94
92
90
88
86
84
82
J F M A M J J A S O N D
Month
36.45
24.30
12.15
0.00
−12.15
−24.30
−36.45

6.1

2. Tidal Ana

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Composite Days

Following the work of *Matthew J. Griffith et al. (2021)* we create a sequence of 4-day composite days.

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Defined at discrete altitudes in 82-98km.

8.1

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Following the work of *Matthew J. Griffith et al. (2021)* we create a sequence of 4-day composite days.

Defined at discrete altitudes in 82-98km.

For radar data **only**.

8.2

Model

$$
\begin{aligned}
y_i = A_0 &+ A_1 \sin(2t_i\pi/24 + \omega_1) \\
&+ A_2 \sin(2t_i\pi/12 + \omega_2) \\
&+ A_3 \sin(2t_i\pi/8 + \omega_3) \\
&+ A_4 \sin(2t_i\pi/6 + \omega_4) + \epsilon_i
\end{aligned}
$$

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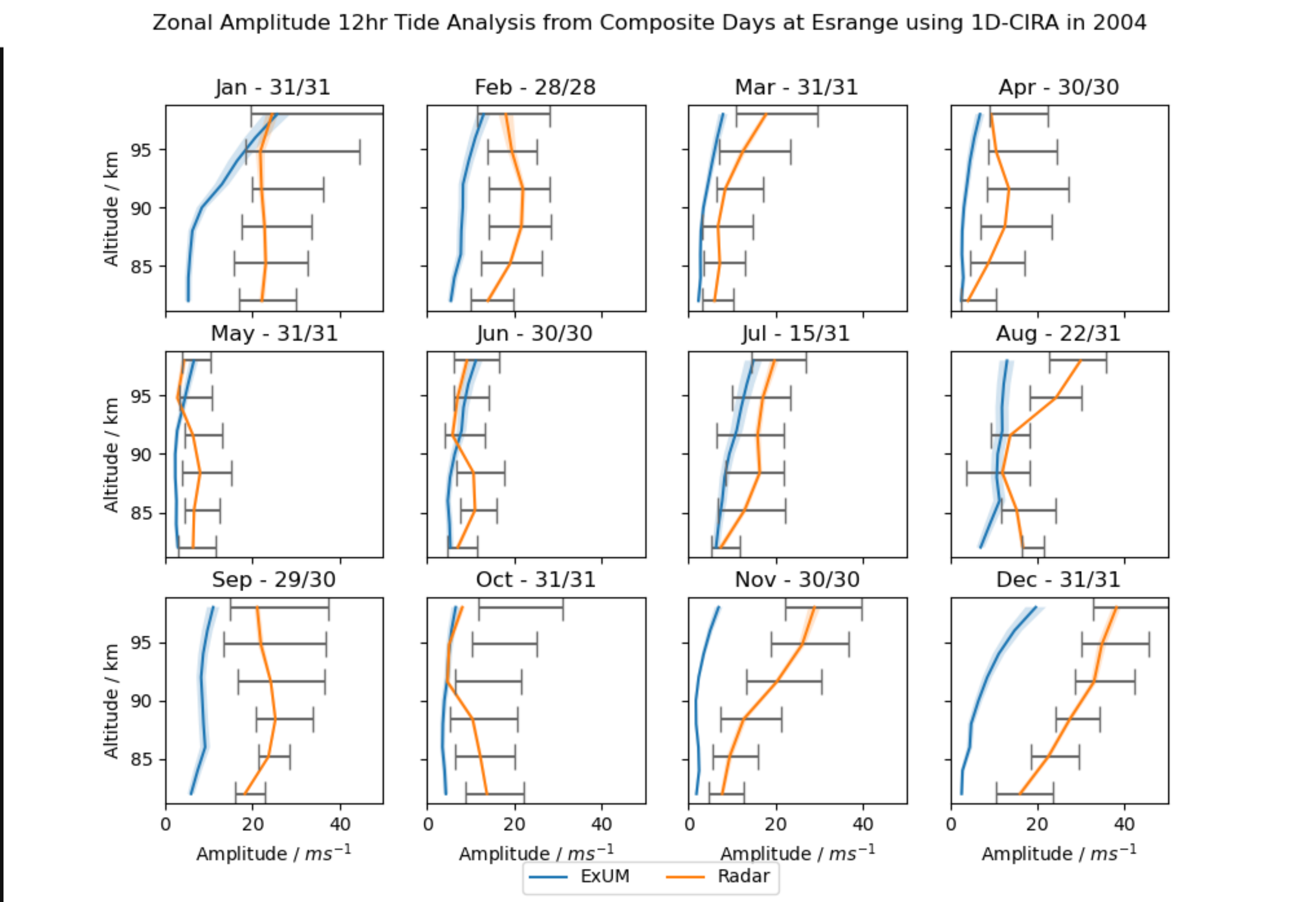
Model

$$
\begin{aligned}
y_i = A_0 &+ A_1 \sin(2t_i\pi/24 + \omega_1) \\
&+ A_2 \sin(2t_i\pi/12 + \omega_2) \\
&+ A_3 \sin(2t_i\pi/8 + \omega_3) \\
&+ A_4 \sin(2t_i\pi/6 + \omega_4) + \epsilon_i
\end{aligned}
$$

ExUM Radar 4-day Composites


Zonal Amplitude 12hr Tide Analysis from Composite Days at Esrange using 1D-CIRA in 2004
Jan - 31/31
Feb - 28/28
Mar - 31/31
Apr - 30/30
May - 31/31
Jun - 30/30
Jul - 15/31
Aug - 22/31
Sep - 29/30
Oct - 31/31
Nov - 30/30
Dec - 31/31
Altitude / km
Amplitude / ms^{-1}
ExUM
Radar

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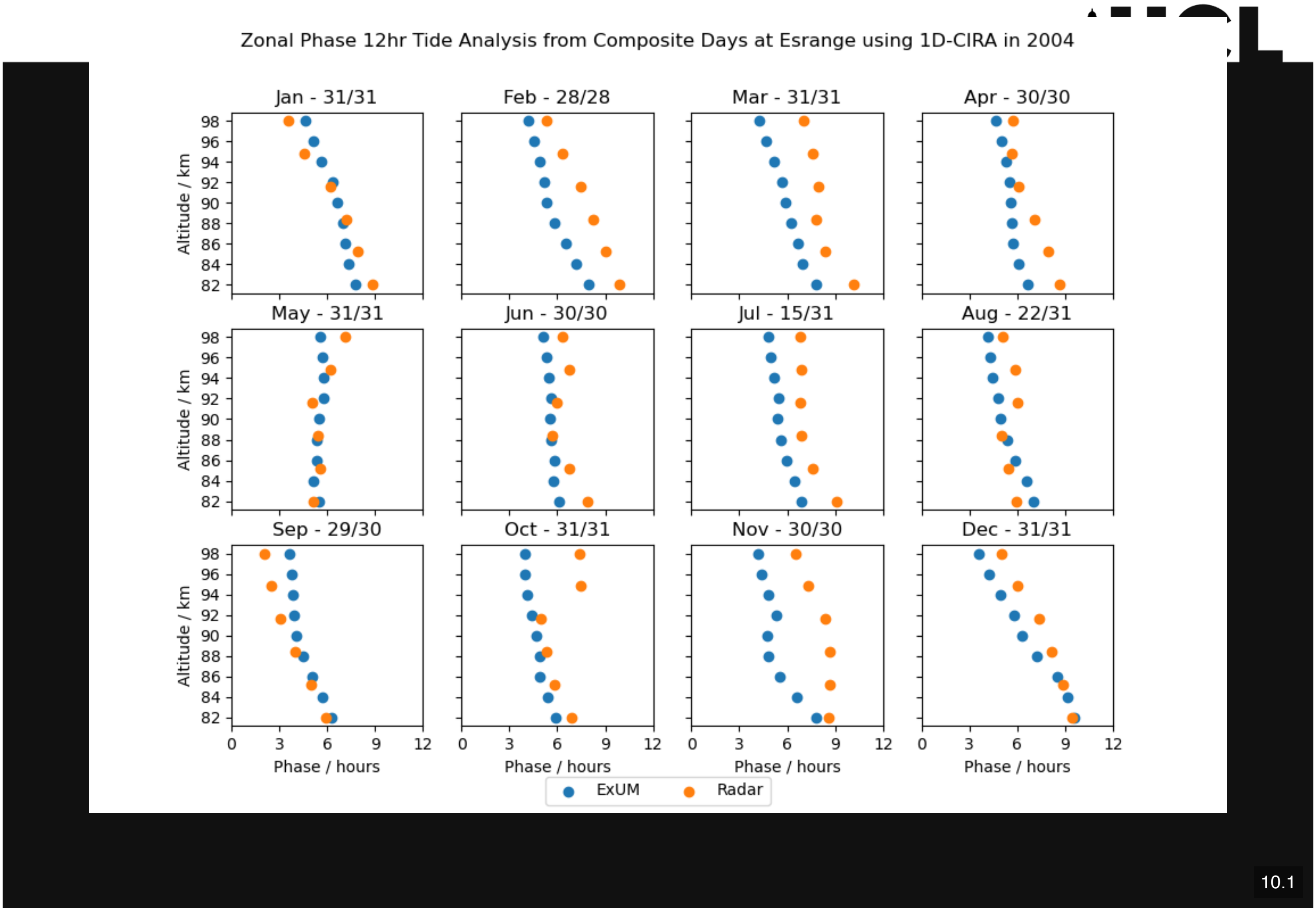
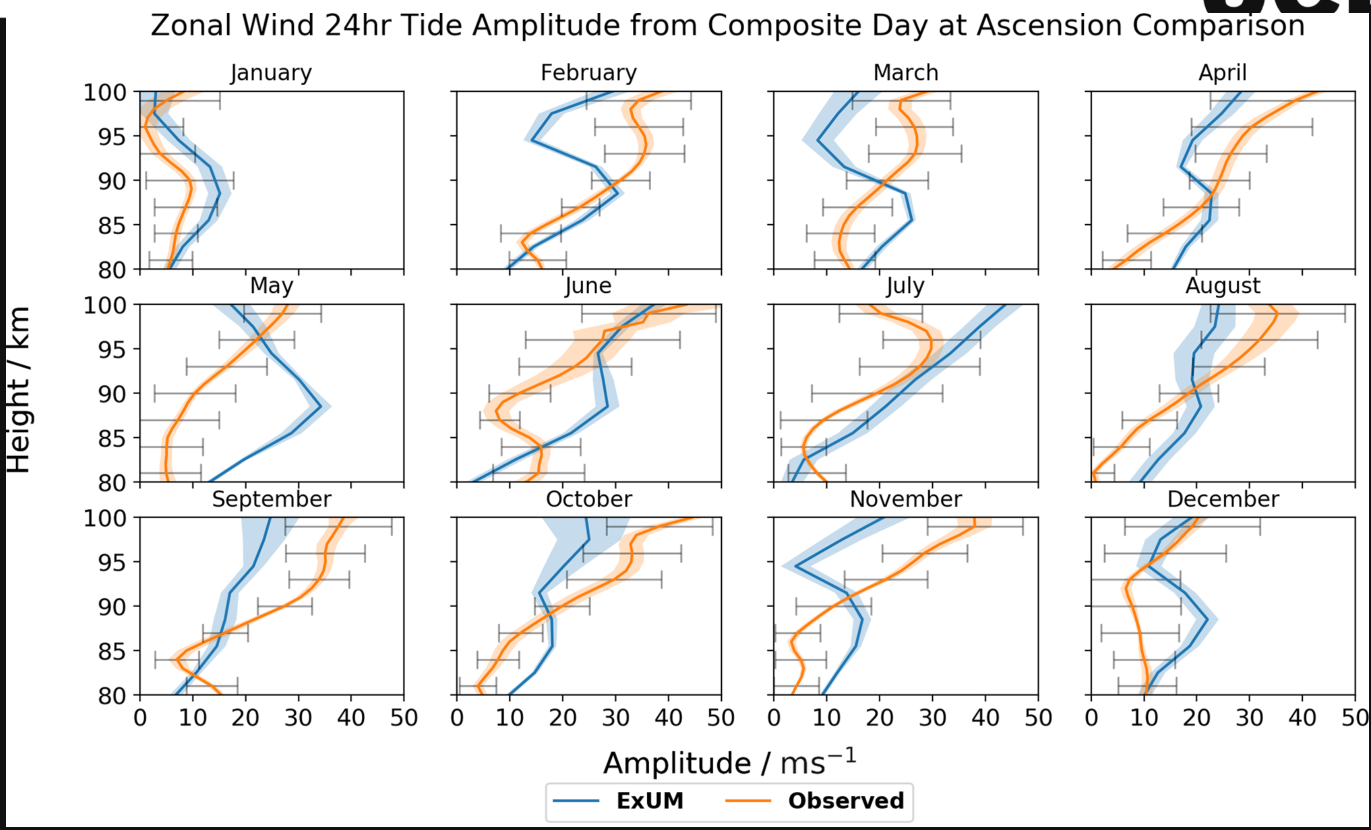

Zonal Phase 12hr Tide Analysis from Composite Days at Esrange using 1D-CIRA in 2004
Jan - 31/31
Feb - 28/28
Mar - 31/31
Apr - 30/30
May - 31/31
Jun - 30/30
Jul - 15/31
Aug - 22/31
Sep - 29/30
Oct - 31/31
Nov - 30/30
Dec - 31/31
Altitude / km
Phase / hours
ExUM
Radar
10.1

"The shaded regions denote the standard deviation from the curve-fitting algorithm, and the black bars indicate the standard deviation from the mean of the measured amplitudes across the month."

10.2


Zonal Wind 24hr Tide Amplitude from Composite Day at Ascension Comparison
January
February
March
April
May
June
July
August
September
October
November
December
Height / km
Amplitude / ms^{-1}
ExUM
Observed

10.3

3. Next S

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More Data

More Data

- More plots requires more simulation data from other years. We have the radar data!

12.1

More Data

- More plots requires more simulation data from other years. We have the radar data!
- Improved regression parameter estimates needs more UM output points. eg hourly output.

12.2

1D-CIRA

$$T_{nudged} = \alpha_{NP} T_{profile} + (1 - \alpha_{NP}) T_{dynamic}$$

$$\text{where} \quad \alpha_{NP} = \frac{k \Delta t}{\tau}$$

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1D-CIRA

$$T_{nudged} = \alpha_{NP} T_{profile} + (1 - \alpha_{NP}) T_{dynamic}$$

$$\text{where} \quad \alpha_{NP} = \frac{k\Delta t}{\tau}$$

- τ chosen to be 24hours in keeping with Song et al. (2018)
- $k \in [0, 1]$ is a 'nudging ramp parameter'.

13.1

1D-CIRA

$T_{profile}$ is based on climatological and satellite data:

- 70-86 km is based on the US Standard Atmosphere (USSA) (COESA, 1976).
- 86-119.7 km is based on the Committee on Space Research (COSPAR) Intern
- 119.7+ km the temperature asymptotes to a selected exobase temperature

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$$T_{\mathrm{PROFILE}}(z) = \begin{cases} T_{70\ \mathrm{km}} - \Gamma_{\mathrm{MESO}}\left(z - z_{\mathrm{USSA-bottom}}\right) & \text{, if } 70 \le z \le 86 \text{ km} \\ T_{70\ \mathrm{km}} - \Gamma_{\mathrm{MESO}}(z_{\mathrm{USSA-top}} - z_{\mathrm{USSA-bottom}}) & \\ \quad -\Gamma_{\mathrm{CIRA}}\left(z - z_{\mathrm{USSA-top}}\right) & \text{, if } 86 < z \le 93.3 \text{ km} \\ T_{70\ \mathrm{km}} - \Gamma_{\mathrm{MESO}}(z_{\mathrm{USSA-top}} - z_{\mathrm{USSA-bottom}}) & \\ \quad -\Gamma_{\mathrm{CIRA}}\left(z - z_{\mathrm{USSA-top}}\right) & \\ \quad +(3 \times 10^{-7})(z - z_{\mathrm{Tmin-CIRA}})^2 & \text{, if } 93.3 < z \le 119.7 \text{ km} \\ T_{\mathrm{exobase}} - \left(T_{\mathrm{exobase}} - T_{\mathrm{CIRA-top}}\right)\exp\left(-\Gamma_{\mathrm{THERMO}}\sigma(z)\right) & \text{, if } z > 119.7 \text{ km} \end{cases}$$

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3D-CIRA

$$T_m(m, \varphi) = T' + T_a \cos(|m - 6|\pi/6) \cos(\pi/2 +$$

$$z_m(m, \varphi) = z' + z_a \cos(|m - 6|\pi/6) \cos(\pi/2 + \varphi$$

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3D-CIRA

$$T_m(m, \varphi) = T' + T_a \cos(|m - 6|\pi/6) \cos(\pi/2 +$$

$$z_m(m, \varphi) = z' + z_a \cos(|m - 6|\pi/6) \cos(\pi/2 + \varphi$$

m = month, φ = latitude

$T' = 178.4482K, T_a = 25.73031K$

$z' = 94.066km$, $z_a = 4.561km$

16.1

3D-CIRA

$$T(m, \varphi, z) = T_m(m, \varphi)\Gamma(z - z_m(m, \varphi))^a$$

3D-CIRA

$$T(m, \varphi, z) = T_m(m, \varphi)\Gamma(z - z_m(m, \varphi))^a$$

$$\Gamma = 4.025643 \times 10^{-6} Kkm^{-1}$$
$$a = 2.414574$$

17.1

DTM

This model is much more complex. Split into 2 parts: 120-170km and 170-200km

It involves polynomial (only quadratic?) fitting to the amplitudes from DTM output.

Eddy Diffusion

K_{zz} drives eddy diffusion and is defined analytically.

It is inferred from SABER atomic oxygen measurements using a similar method to the tidal analysis seen earlier.

[RD-25] says K_{zz} varies with the solar cycle.

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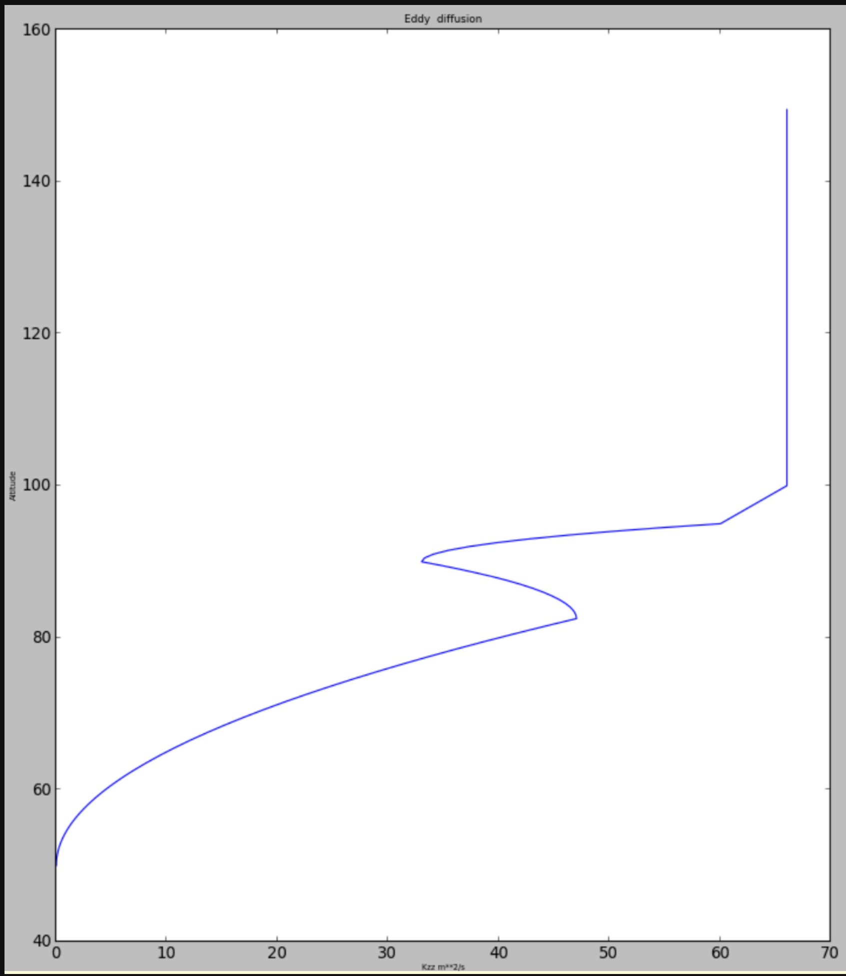
Eddy diffusion
Altitude
Kzz m**2/s
160
140
120
100
80
60
40
0
10
20
30
40
50
60
70

20