GRAVITY WAVE DETECTION
Gravity Waves
Gravity Waves
Gravity Waves
Radiosonde Data

Graw DFM-17
Radiosonde

Sensor Array

Styrofoam Housing
Radiosonde Data

30 meters
Radiosonde Data
Radiosonde Data
Radiosonde Data
Radiosonde Data
Radiosonde Data

Radiosonde Data Collected by MSGC, 2020

Zonal Wind [m/s]  Meridional Wind [m/s]

Altitude [km]

Flight Hodograph

Zonal Wind [m/s]  Meridional Wind [m/s]
Hodograph Method
WAVELET METHOD
Wavelet Transform

\[
\psi_0 = \frac{\pi^{-1/4}}{e^{i\omega_0}} e^{-\eta^2/2}
\]

For a time series \(x_n\) with step \(\Delta t\) and length \(N\),

\[
W_n = \sum_{k=0}^{N-1} x_k \psi^*(\frac{(k-n)\Delta t}{s})
\]
Wavelet Transform

\[ \psi_0 = \frac{\pi^{-1}}{4} e^{i\omega_0 \eta} e^{-\eta^2/2} \]

\[ W_n = \sum_{k=0}^{N-1} x_k \psi^*(k-n) \Delta t \]

\[ \int s(x) * w \left( \frac{x-\Delta}{\sigma} \right) \, dx \]
Power Surface

\[ P_n(s) = |U_n(s)|^2 + |V_n(s)|^2 \]

\[ \lambda = \frac{4\pi s}{\omega_0 + \sqrt{2 + \omega_0^2}} \]
Power Surface
Time Series Reconstruction

\[ x_n = \frac{\delta j \sqrt{\delta t}}{C_\delta \psi_0(0)} \sum_s \frac{W_n(s)}{\sqrt{s}} \]
Half Max Power Filtering

[Graph showing wind variance and altitude]
Stokes Parameters

\[ \theta = \frac{1}{2} \tan^{-1} \left( \frac{2 \text{Re}\{u\} \text{Re}\{v\}}{\text{Re}\{u\}^2 - \text{Re}\{v\}^2} \right) \]  
\[ \hat{\omega} = f \frac{u_\parallel}{v_\perp} \]  
\[ k_h^2 = \frac{f^2 m^2}{N^2} \left( \frac{\hat{\omega}^2}{f^2} - 1 \right) \]  
\[ \hat{c} = \frac{\hat{\omega}}{k_h} \]

- Direction of Propagation
- Intrinsic Frequency
- Horizontal Wavenumber
- Intrinsic Horizontal Phase Speed
Example Output

```
"wave1": {
  "Altitude [km]": 18.261,
  "Latitude [deg]": 46.5748954,
  "Longitude [deg]": -113.587986,
  "Date and Time [UTC]": "2020-06-19 18:46:40.600000",
  "Vertical wavelength [km]": 1.733478945744944,
  "Horizontal wavelength [km]": 8555.516516427581,
  "Propagation direction [deg]": 102.63933566040487,
  "Axial ratio [no units]": 1.0626199666181267,
  "Intrinsic vertical group velocity [m/s]": -0.000362065855403367,
  "Intrinsic horizontal group velocity [m/s]": 1.78993863434342757,
  "Intrinsic vertical phase speed [m/s]": 0.003170037434321487,
  "Intrinsic horizontal phase speed [m/s]": 15.64742578789683,
  "Degree of Polarization [no units]": 0.9186031079507199
},
"wave2": {
  "Altitude [km]": 20.246,
  "Latitude [deg]": 46.571177,
  "Longitude [deg]": -113.599177,
  "Date and Time [UTC]": "2020-06-19 18:53:39",
  "Vertical wavelength [km]": 3.1792137600671246,
  "Horizontal wavelength [km]": 5629.05064029162,
  "Propagation direction [deg]": 126.658214030291712,
  "Axial ratio [no units]": 1.5387364154793317,
```

UM BOREALIS SUMMER FLIGHTS
UM BOREALIS SUMMER FLIGHTS

Radiosonde Data Collected by MSGC, 2020

Altitude [km]

Time [UTC]

Radiosonde flight
Gravity Wave
Future Research

- Total solar eclipse 2020 ballooning campaign
- Investigate choice of wavelet scales
- Improve wave outlining algorithm
- Improved automated wave validity checks
- Statistical significance testing
- Test other methods for background removal
- Graphical User Interface
Sources

- Jacques Descloitres, MODIS Rapid Response Team, NASA/GSFC

- https://www.eol.ucar.edu/deepwave/eo


- https://svg-clipart.com/black/xmm2Yhp-parachute-clipart


- https://upload.wikimedia.org/wikipedia/commons/9/95/Continuous_wavelet_transform.gif