Energy Flux Diagnostic and Predictions

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Energy Flux

• Energy flux is the product of perturbation pressure and vertical velocity:

\[ EF_z = p'w' \]

• In idealized mountain wave studies, the perturbation is defined relative to some mean value that doesn’t vary in space.

• In the atmosphere and in realistic simulations, large scale pressure variations exist in geostrophic balance with large scale winds.

• Demeaning fields leaves large scale perturbations unrelated to gravity waves.
Perturbation Quantities

• To address this, we high pass filter
• Filtering is performed using a 2-D isotropic Gaussian high pass filter in Fourier space and inverting
• With the high passed perturbation field, the low passed field can by found by subtracting the high passed field from the full field
• In this way, fields are partitioned into a smoothly varying background part and the high passed part retaining perturbations from gravity waves:

\[ p = p_{lp} + p_{hp} = \bar{p} + p' \]
Filtering Caveats

• Only use one level and one time to separate between large and small scale features

• Edge artifacts exist due to aperiodic boundaries

• Some sensitivity to cutoff length scale
EF Calculation

• The energy flux is calculated in four steps:
  1. Model variables interpolated to constant height levels
  2. High pass filtering performed to produce perturbation fields
  3. Perturbation pressure and vertical velocity fields are multiplied point-wise
  4. An additional 150 km low pass filter is applied
     – Evaluates EFz sign locally while retaining spatial extent
     – Low passed EFz values highly sensitive to LP length scale
Operational EF Diagnostic Status

• Currently, this diagnostic has been implemented in three operational models:
  1. 15 km COAMPS
  2. 12 km NIWA
  3. 6 km Innsbruck WRF

• Initially, contour spans were targeted at significant orographic cases

• Saw very little flux values with the weaker flow during the beginning of the project

• Logarithmic contour intervals implemented by Alex were quite revealing
RF01 4 km EF
Non-Orographic Examples
700 hPa Winds Prediction Comparison for RF05

6 km Innsbruck WRF

WRF
Init: 2014-06-16_00:00:00
Valid: 2014-06-16_12:00:00

Windspeed (m s⁻¹) at 700 hPa
Geopot. height (m) at 700 hPa
Wind Vector (m s⁻¹) at 700 hPa

15 km COAMPS

Field — fill = Wind Speed (m s⁻¹)
Field — contour = Geopotential Height (dm)
Level = 700 hPa

12 km NIWA

NIWA NZLAM-12: Geopotential(m) & Wind Speed (ms⁻¹) at 700 hPa
Forecast Range: 12 h, Valid at 1200:16-Jun-2014 (UTC)
4 km EF Prediction Comparison for RF05

6 km Innsbruck WRF

WRF
Init: 2014-06-16_00:00:00
Valid: 2014-06-16_12:00:00

Vertical energy flux (W m$^{-2}$) at 4 km

15 km COAMPS

Field = Energy Flux (W m$^{-2}$) Level = 4 km
Forecast Range: 12 h, Valid at 1200:16-Jun-2014 (UTC)

12 km NIWA

Wave energy flux (W m$^{-2}$)
13 km EF Prediction Comparison for RF05

6 km Innsbruck WRF

WRF
Init: 2014-06-16_00:00:00
Valid: 2014-06-16_12:00:00

Vertical energy flux (W m$^{-2}$) at 13 km

15 km COAMPS

Field = Energy Flux (W m$^{-2}$) at 13 km

12 km NIWA

NIWA NZLAM-12: Wave Energy Flux at: 13000 m
Forecast Range: 12 h, Valid at 1200:16-Jun-2014 (UTC)
# RF05 EF Prediction Comparison

## 16 June 2014 @ 12 Z, 00Z Initialization

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<thead>
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<th>W m-2</th>
<th>4 km EF</th>
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## 16 June 2014 @ 15 Z, 00Z Initialization

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Conclusions

• Strong low level EF result from cross barrier flow
• Strongest fluxes are seen in orographic cases, but non-orographic wave structures do have weaker but positive EF
• EF values are comparable between the NIWA and NRL model
• 6 km resolution simulations produce EF values > lower resolution models
  – Suggests shorter unresolved wavelengths have an important EF contribution
• Interesting weak negative fluxes frequently simulated, but only in the troposphere
Low passed pressure field

- Pressure LP @ 300 km (Pa) at 4 km
- Pressure LP @ 300 km (Pa) at 4 km

High passed pressure field

- Pressure HP @ 300 km (Pa) at 4 km
- Pressure HP @ 300 km (Pa) at 4 km

Map showing pressure fields with contour lines and color coding.