Numerical modeling of gravity waves above the jet stream during SCATCAT.

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SCATCAT – *Severe Clear Air Turbulence Colliding with Aircraft Traffic*  *(An experiment funded by the FAA)*

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Background and motivation.

SCATCAT was a field experiment designed to examine Clear Air Turbulence associated with the jet stream and upper-level frontal structures (Feb 2001 – based out of Hawaii).

Observations using NOAA’s Gulfstream-IV aircraft.
- In-situ measurements of turbulence and ozone.
- Closely spaced dropsondes.

Focus on observations surrounding 0Z 18 February 2001.
- Intense jet stream / upper warm front north of Hawaii.
- 17 Dropsondes with an average spacing of 40 km.
- Observed gravity waves.
- In-situ turbulence – in region of gravity waves

Focus of this study is on fine-scale modeling of the jet/front system in an attempt to produce similar structures to those observed (in particular the gravity waves). Attempt to understand processes generating turbulence in this case.
COAMPS 24 hour forecast (valid 0Z 18 Feb 2001).
Surface pressure and wind speed at 9 km shaded at 50, 60, 70 m/s.

Track of G-IV during dropsonde release.
**Modeling Strategy.**

Attempt to resolve fine scale mesoscale structures in the jet / front system to reproduce gravity wave structures and understand turbulence generation mechanisms.

COAMPS forecast from nested run:

- Two domains (DX=54 km, 18 km, DZ=400 m).
- 30 Hours forecast (0Z 2/17/01 – 6Z 2/18/01)

Use COAMPS Domain 2 to initialize and provide boundary conditions for the Clark model.

Exploit the Clark model’s ability to be multiply (two-way) nested. Focus in on fine scale features using horizontal and vertical grid refinement.

- \( DX=6 \text{ km} \ DZ=400 \text{ m} \rightarrow DX=1 \text{ km} \ DZ=50 \text{ m} \) in 4 domains
Nested grids from Clark model

Domain 3
\(dx=3\ \text{km}\)
\(dz=100\ \text{m}\)

Domain 4
\(dx=1\ \text{km}\)
\(dz=50\ \text{m}\)
Wind speed from Domain 3 at 6 Z – DX=3 km, DZ=100 m
Pot. Temp. (2K intervals) Domain 3 at 6 Z – DX=3 km, DZ=100 m
Richardson number from Domain 3 at 6 Z – DX=3 km, DZ=100 m
Sub-grid TKE from Domain 4 at 6 Z – DX=1 km, DZ=50 m

Max approx 0.4 m²/s²
Sub-grid TKE at 11 km from Domain 4 at 6 Z – DX=1 km, DZ=50 m

TKE and PT at 11 km

X (km)

Y (km)

3.33
3.34
3.35
3.36
3.37
3.38
3.39

50 100 150

50 100 150
Wind speed from Domain 4 at 6 Z – DX=1 km, DZ=50 m
Resolved TKE from Domain 4 at 6 Z – DX=1 km, DZ=50 m

Max approx 1 m²/s². Horiz. Scales less then 20 km
**Summary.**

Use multi-model multi-domain approach to investigate gravity wave generation by jet / front system.

Produce similar structures to observed. Can only make qualitative comparisons because of scales. Limited by synoptic forecast – lack of observations in Pacific.

Waves generated at the same time as upper-level frontogenesis, but also have the same horizontal scale as the tropopause fold, and mesoscale jet structures. Difficult to separate source and response.

Waves with 150 km wavelength propagate through the strong shear layer at the top of the jet. The waves perturb the Richardson number and cause coherent bands of low and high Ri.

Waves do not break – no convective overturning– but will cause turbulence and mixing due to shear instabilities.
PV at 1, 1.5, 2, 3, 5 PVU from 3 km, 100 m run at 6Z
$V$ at $Z=11.3$ km (37000 ft)
COAMPS 24 hour forecast (valid 0Z 18 Feb 2001).
Wind vectors at 9 km. Wind speed shaded at 50, 60, 70 m/s.

Track of G-IV during dropsonde release.