Large-Amplitude Stratospheric Gravity Waves

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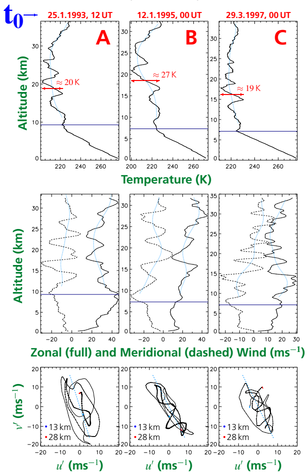
Measurements

3 selected large-amplitude stratospheric gravity wave cases based on high-resolution radiosonde temperature profiles from Munich-Oberschleißheim (**MO**, 48°N, 12°E):



unperturbed background state: high-pass filter within the range $[z_{TP}+2\,\mathrm{km}, z_{max}]$, cutoff wavelength $= 10\,\mathrm{km}$

perturbation profile: local deviations (T', u', v') from background state ($\overline{T}$, $\overline{u}$, $\overline{v}$)

$\Rightarrow$ spectral analyses

Wave Parameters

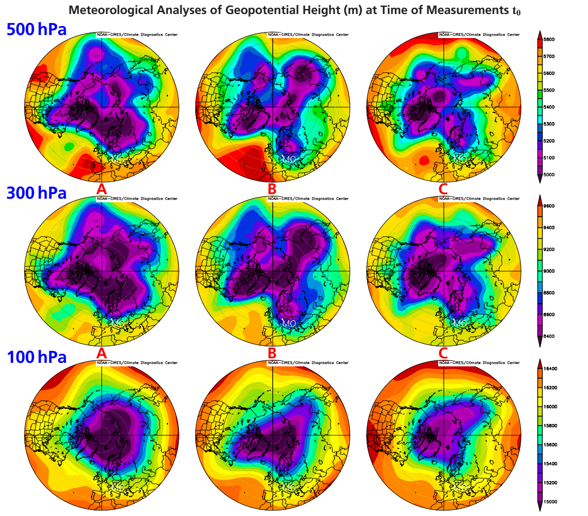
	A	B	C
E_{pot} / Jm^{-3}	3.72	4.13	2.79
E_{kin} / Jm^{-3}	5.45	5.59	4.95
λ_h / km	218	114	143
λ_v / km	4.6	5.5	3.6
f/ω	3.4	7.7	4.1
c_i / ms^{-1}	12.8	15.1	10.2
F	0.76	0.63	0.68
Θ_{prop} / deg	342	331	334

$E_{pot} = \frac{1}{2}\overline{\rho}g^2\langle (T'/\overline{T})^2\rangle/\overline{N^2}$ (potential energy)
$E_{kin} = \frac{1}{2}\overline{\rho}(\langle u'^2\rangle + \langle v'^2\rangle)$ (kinetic energy)
$\lambda_{h,v}$ - horizontal & vertical wavelength
f/ω - ratio of inertial to intrinsic frequency
c_h - intrinsic phase speed
F - fraction of upward going energy
Θ_{prop} - propagation direction

Left: wind fluctuation hodographs, the mean orientation of the ellipse (blue dashed lines) gives the propagation direction ($\pm 180°$)

Global-Scale View

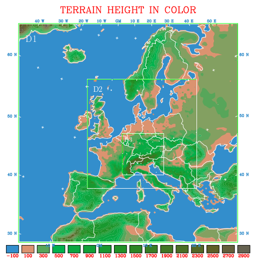
Meteorological Analyses of Geopotential Height (m) at Time of Measurements t_0



Data provided by NOAA-CIRES/Climate Diagnostics Center (http://www.cdc.noaa.gov)

Mesoscale Simulations

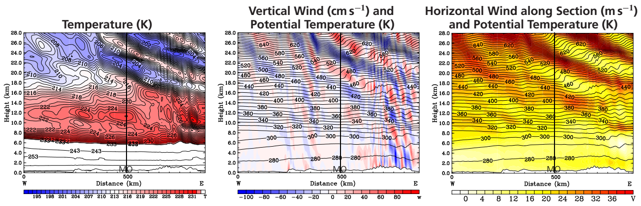
MM5 Setup



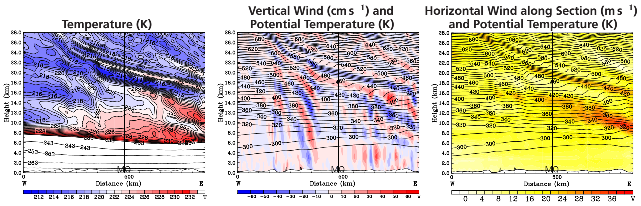
- MM5 - version 3.4, driven by ECMWF - analyses (T213L31, lat×lon $\approx 1.125° \times 1.125°$)
- up to 3 domains: 128, 192, 225 grid points and 36, 12, 4 km horizontal mesh size
- top at 10 hPa, 210 levels (≈ 150 m vertical mesh size)
- modified upper radiative boundary condition (introduced by G. Zängl)
- without radiation and moist processes
- MRF boundary layer parameterisation

Vertical Sections - D3

Case B - initialized at $t_0 - 24$ h, shown at $t_0 + 1$ h



Case C - initialized at $t_0 - 12$ h, shown at $t_0 + 1$ h



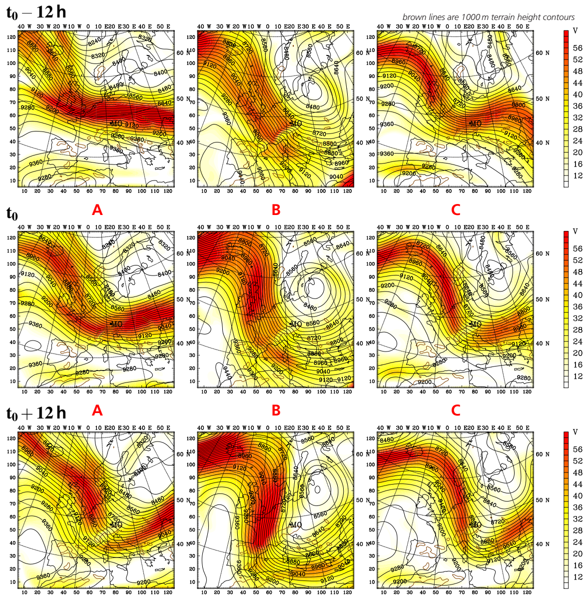
The positions of the vertical sections are shown in the corresponding horizontal sections of divergence and vertical wind on the right hand side (highlighted in green).

What could be the Cause of the Large-Amplitude Stratospheric Gravity Waves?

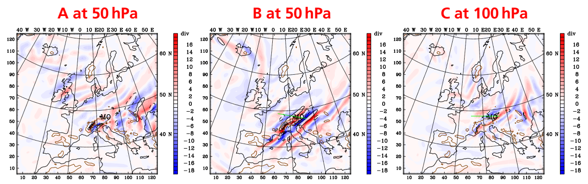
- interaction of intense jet streams with flow-blocking features like the Alps can intensify ageostrophic motions $\Rightarrow$ enhanced geostrophic adjustment?
- large scale unstable baroclinic waves $\Rightarrow$ smaller scale gravity waves?
- ?

Horizontal Sections - D1, initialized at $t_0 - 36$ h

Geopotential Height (m, contours) and Horizontal Wind (m s^{-1}, colored) at 300 hPa

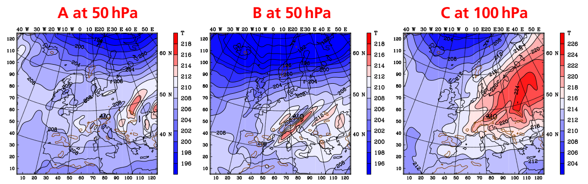


Divergence (10^{-5}s^{-1}, colored) and Vertical Wind (cm s^{-1}, contours every 10 cm s^{-1}, negative dashed) at t_0



brown lines are 1000 m terrain height contours

Temperature (K) at t_0



We acknowledge the free availability of the radiosonde data provided by the DWD Oberschleißheim.

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