Wave signatures in water vapor and cloud formation

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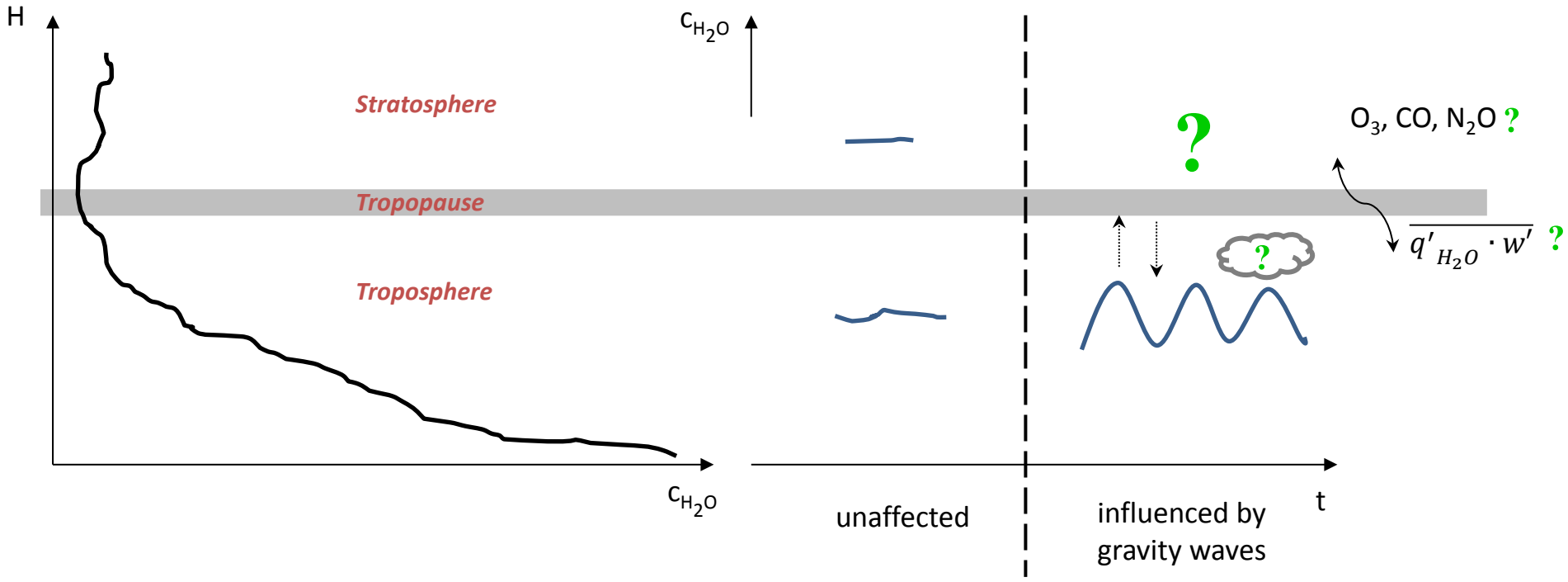
WRF Simulations: Johannes Wagner

DLR

How gravity waves might influence water vapor fields



- Combined measurements of water vapor and total water to detect signature of gravity waves

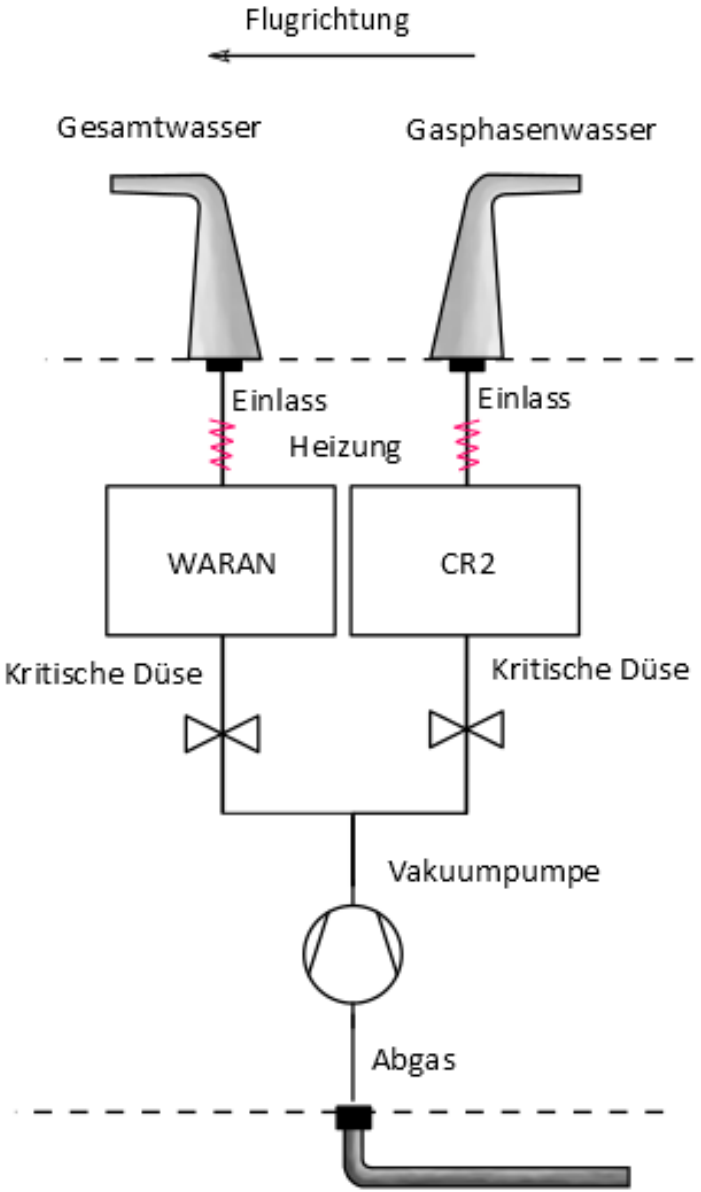
Instruments

CR-2: Gas phase H_2O

- Buck CR-2 Dew Point Mirror
- Range: ~1…20000 ppmv
- Resolution: >10 s

Waran: Total H_2O

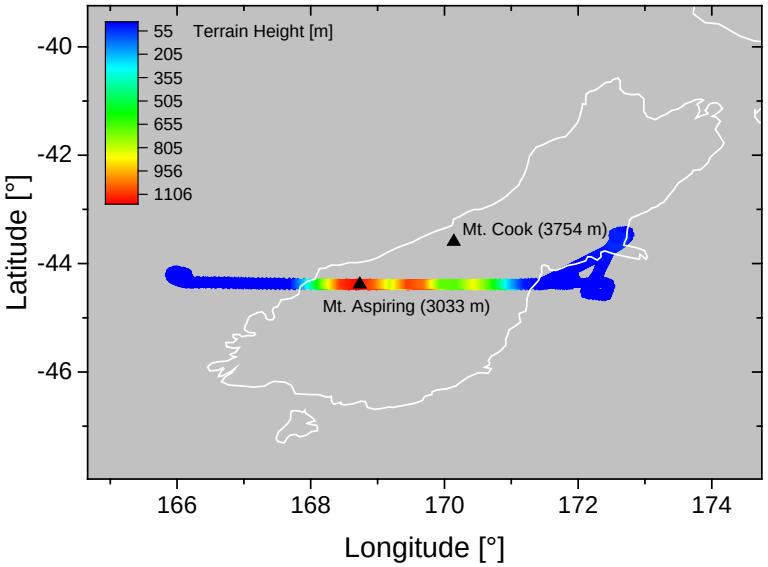
- WVSS-II Tunable Diode Laser (1,37µm)
- Range: ~50…40000 ppmv
- Resolution: ~3 s
- Enhancement correction for ice particles

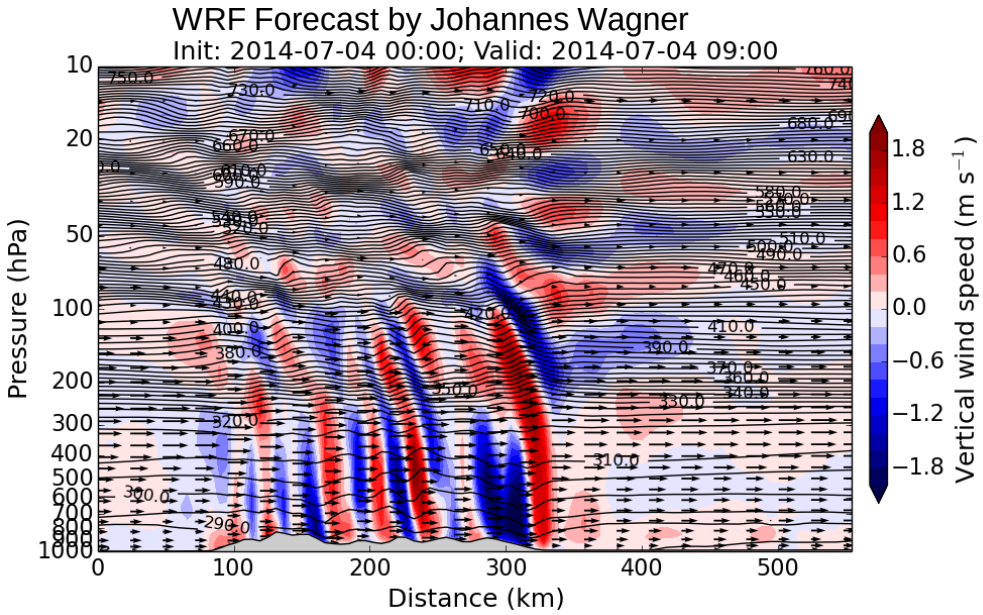


1. Gravity wave signatures in water vapor
2. Formation of lee wave cirrus

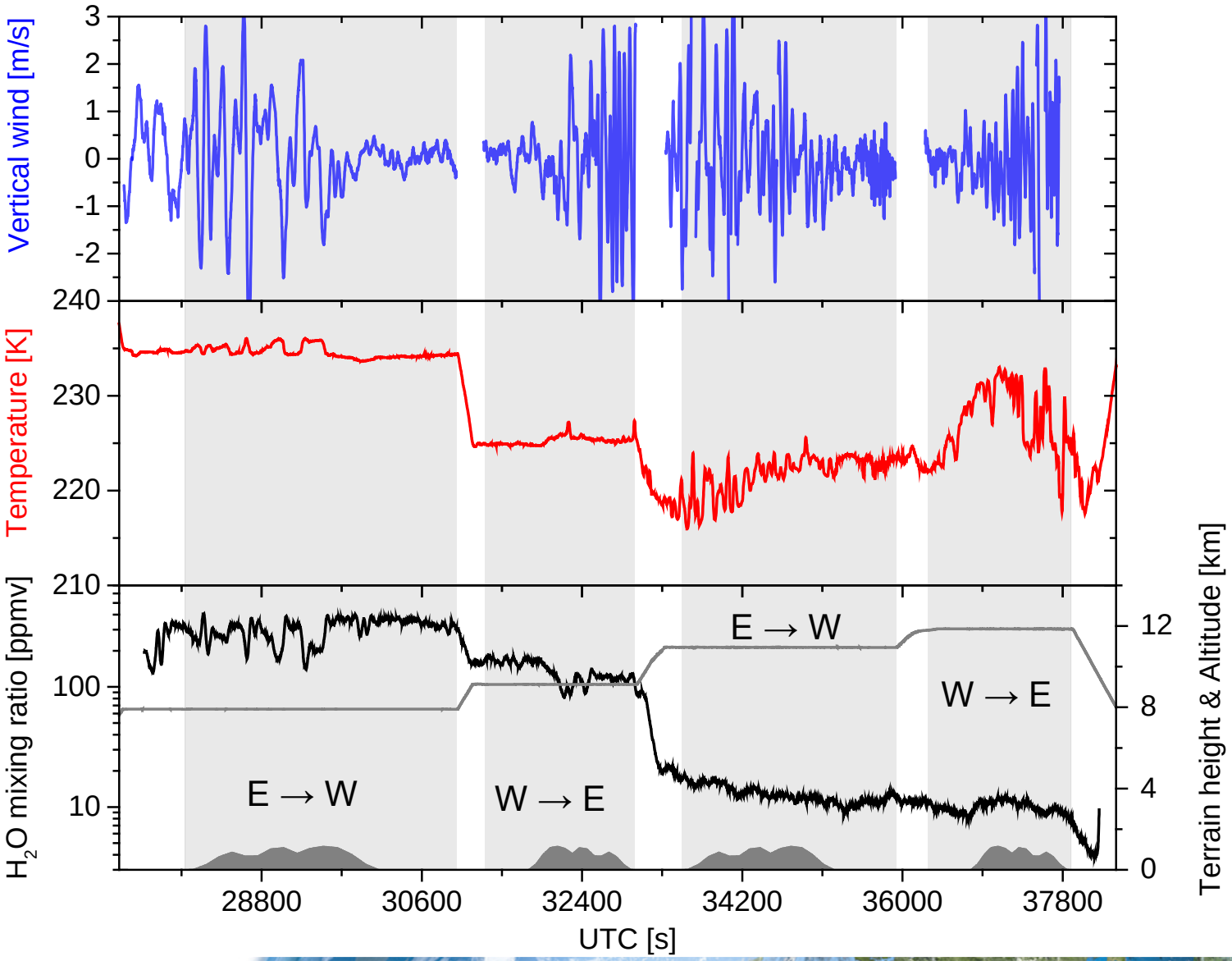
Wave signatures in tropospheric water vapor

- IOP 10, flight F05 on 4/5 July 2014
- Mountain wave event under WSW flow
- Mt. Aspiring transect
- Example for distinct wave pattern in water vapor signal in the troposphere

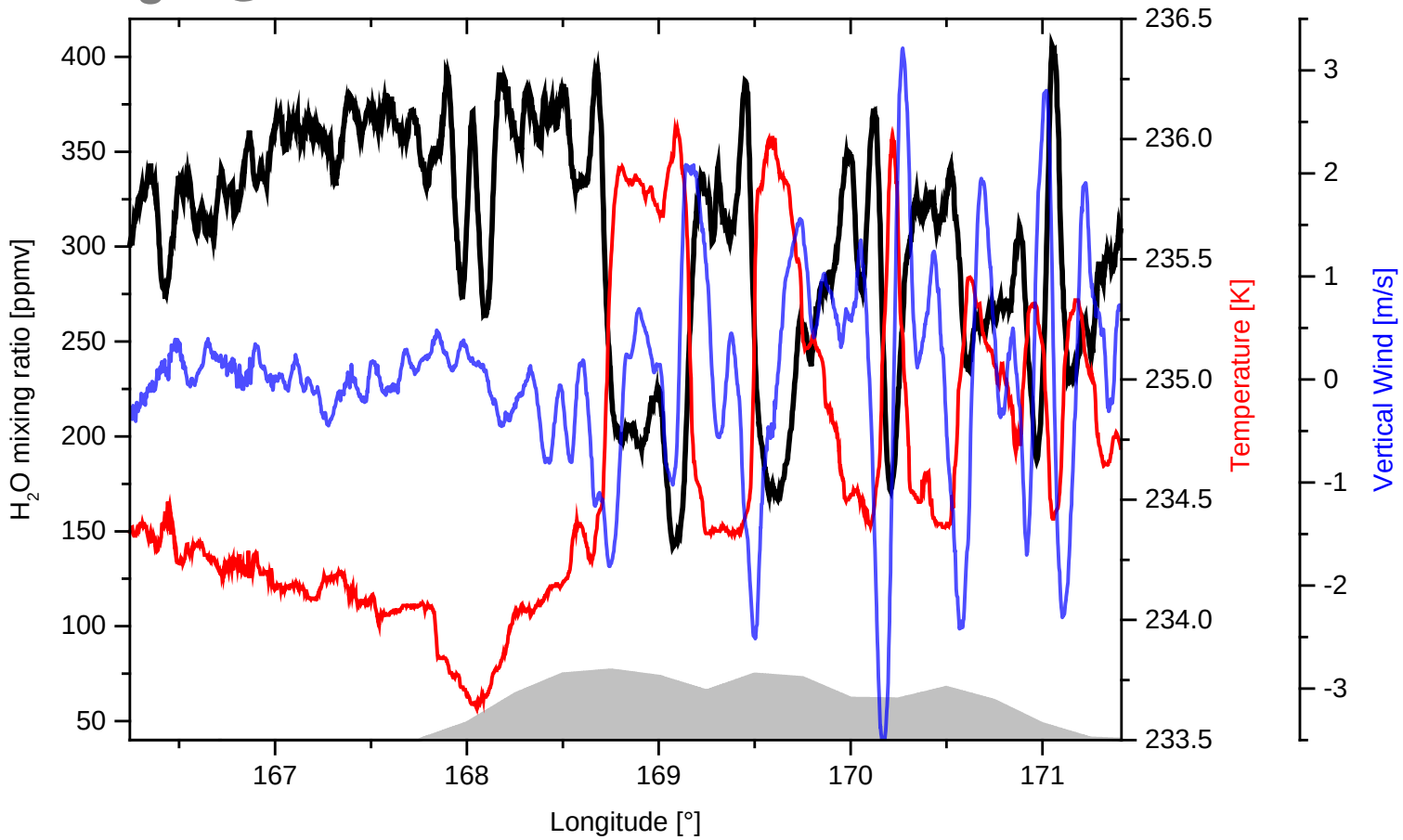




H_2O, Temperature & Wind @ flight 140704b



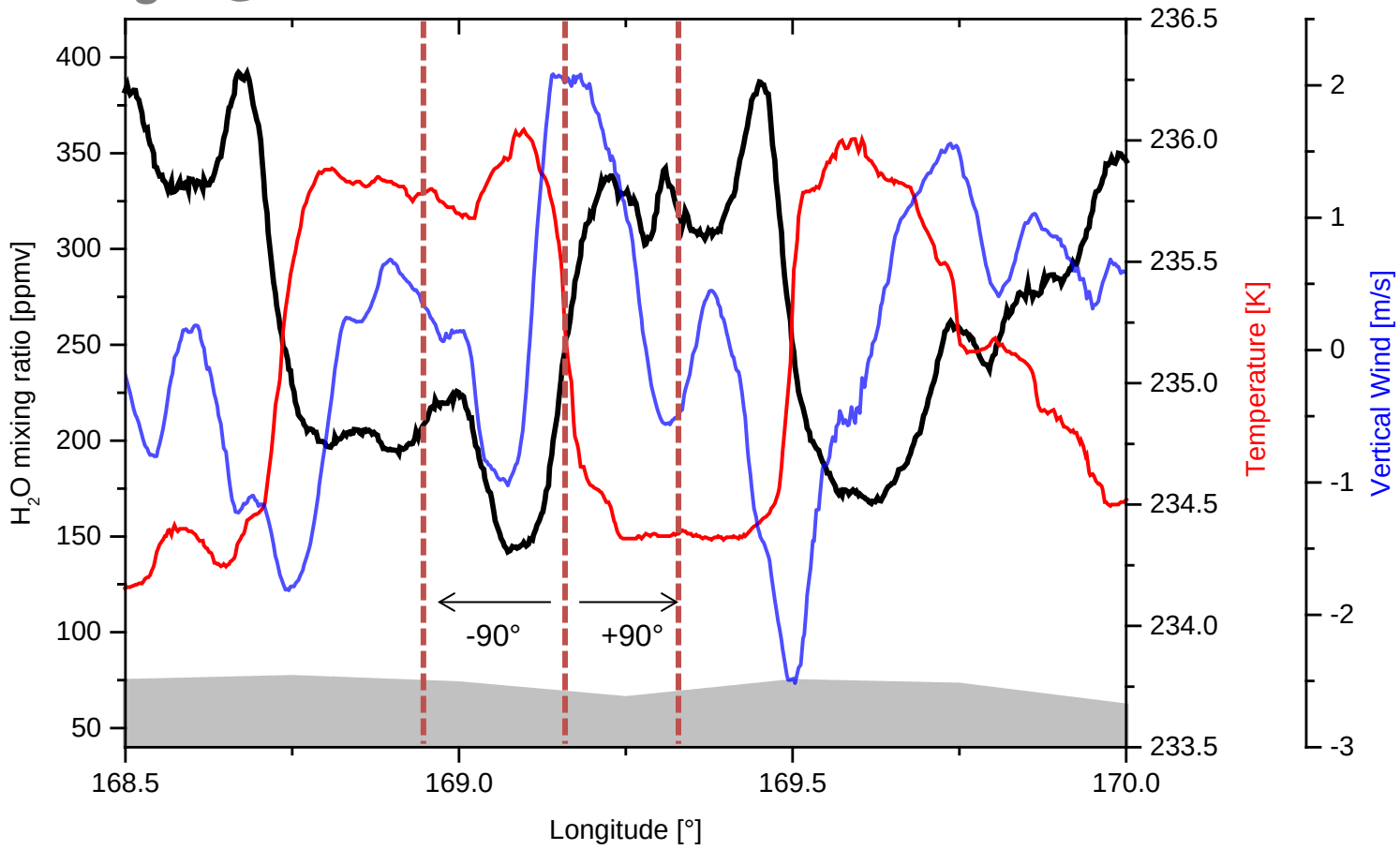
Leg 1 @ 7908 m



- Anticorrelation of H_2O and Temperature
- H_2O minima: downward transport of dry air & adiabatic heating
- H_2O maxima: upward transport of moister air & adiabatic cooling

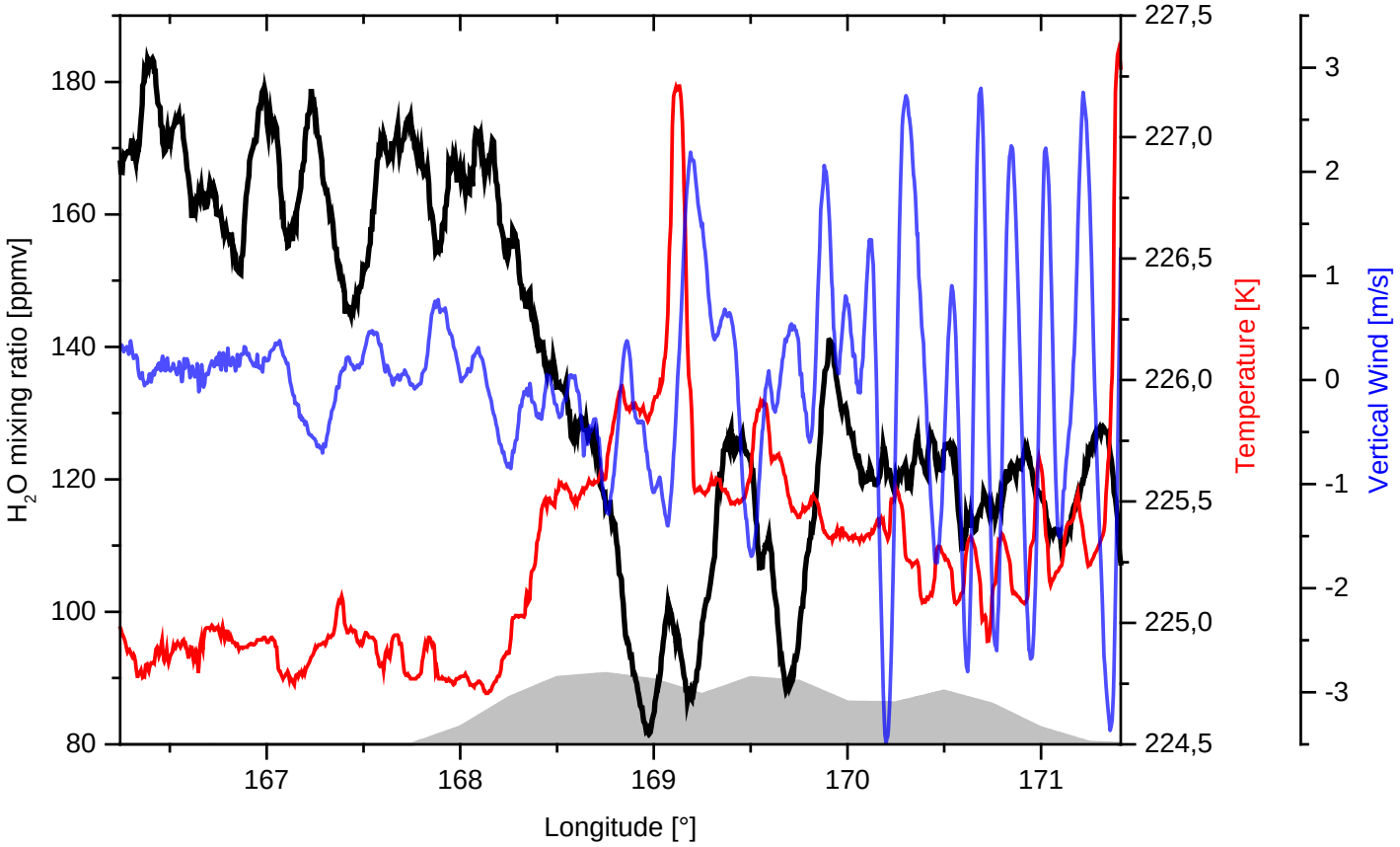
- Amplitude: ~ 150 ppmv
- Strong downwind peak initializes water vapor drop

Leg 1 @ 7908 m



- ±90° phase shift between vertical wind and water vapor/temperature
- Maxima and minima in water vapor consistent with vertical displacement

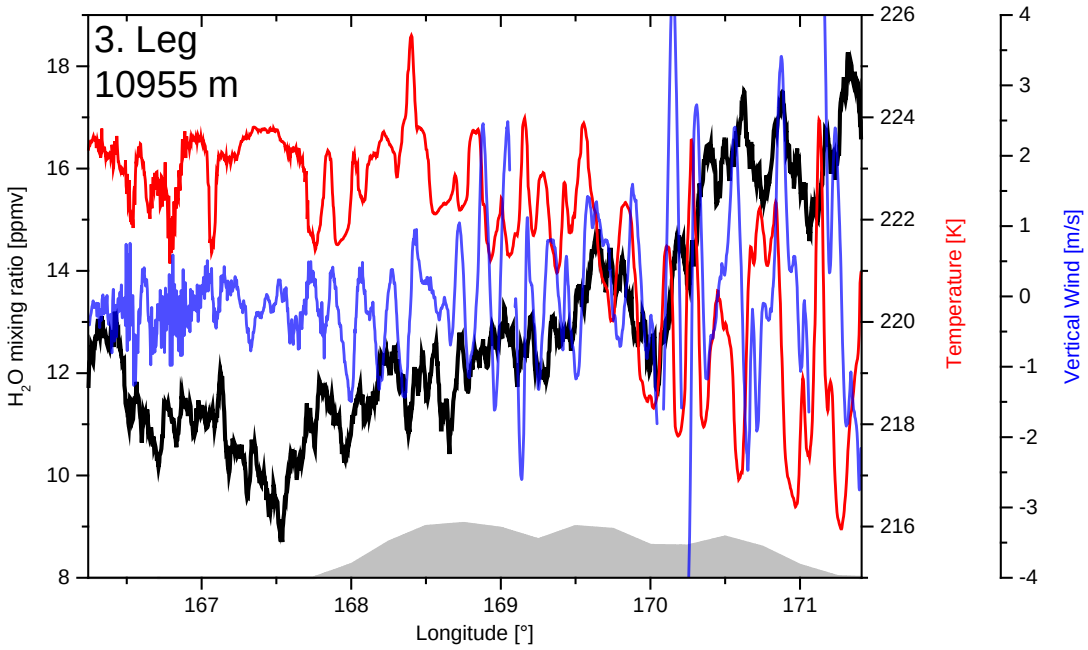
Leg 2 @ 9125 m

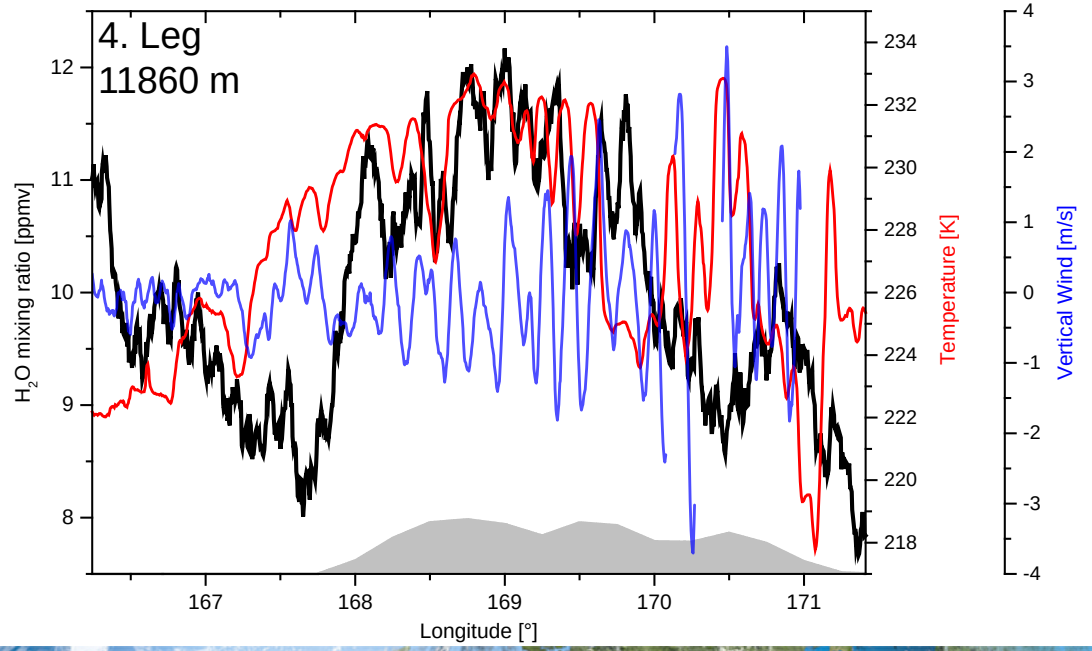


- Similar features but significantly lower amplitude of 20-30 ppmv
- Shorter wavelength (~10 km) at the mountain lee side in vertical wind and temperature

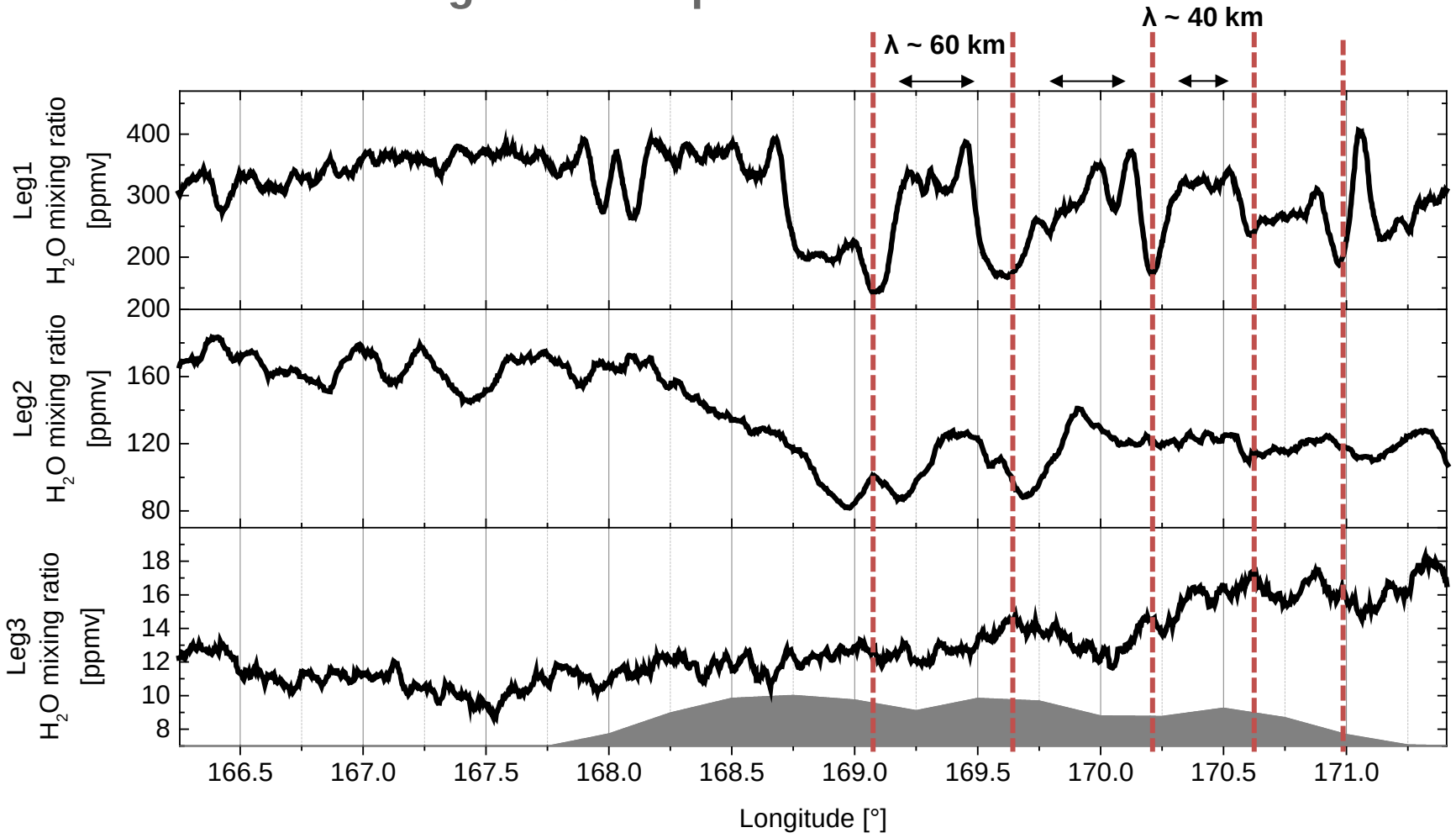
Lower Stratosphere

- No significant wave signature in water vapor
- Pronounced wave activity in temperature and vertical wind





Horizontal wavelengths & comparison with WRF



- Clear wave signature only seen in the troposphere
- Wavelengths 40-60 km → Comparable to WRF model

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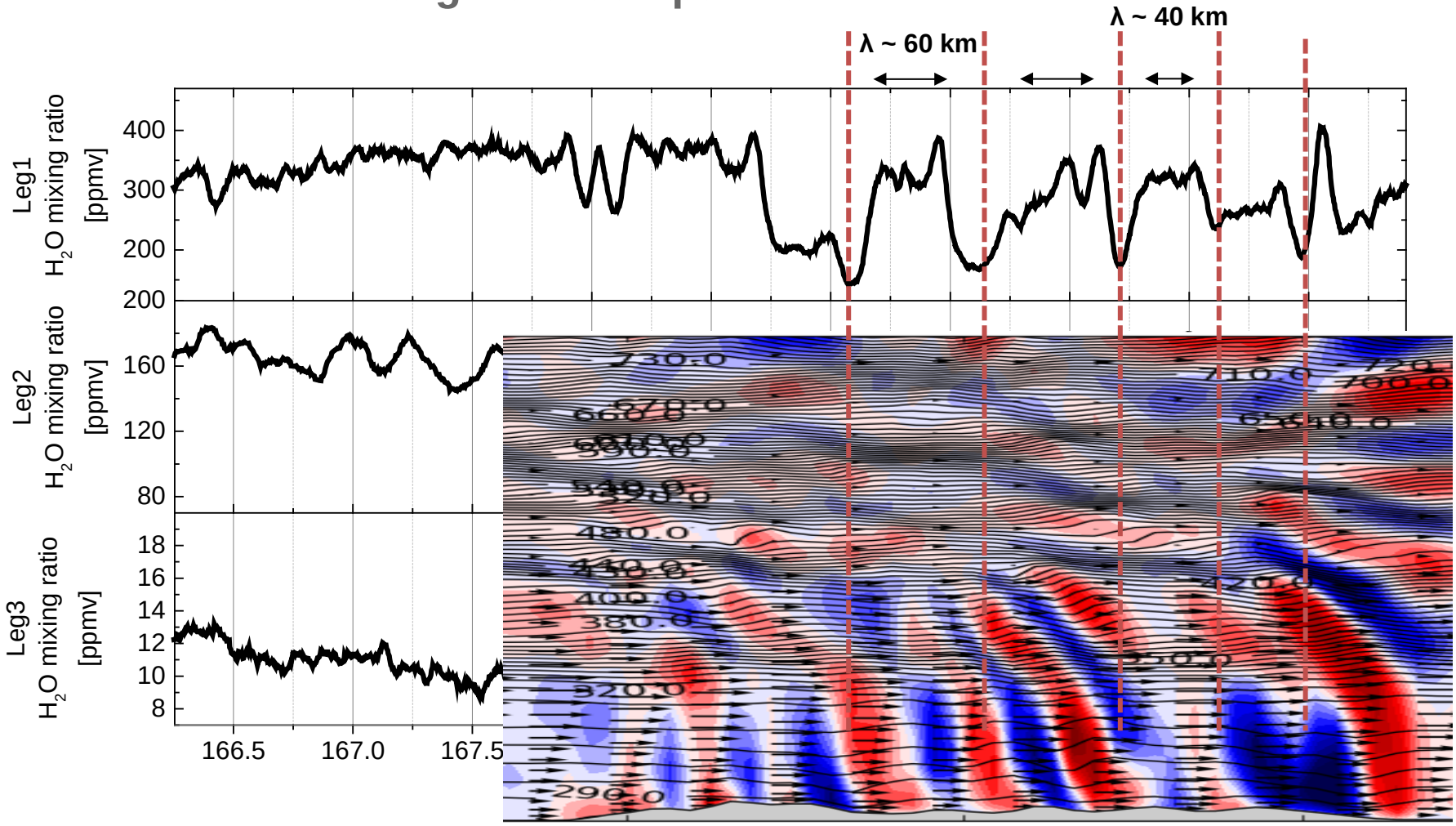

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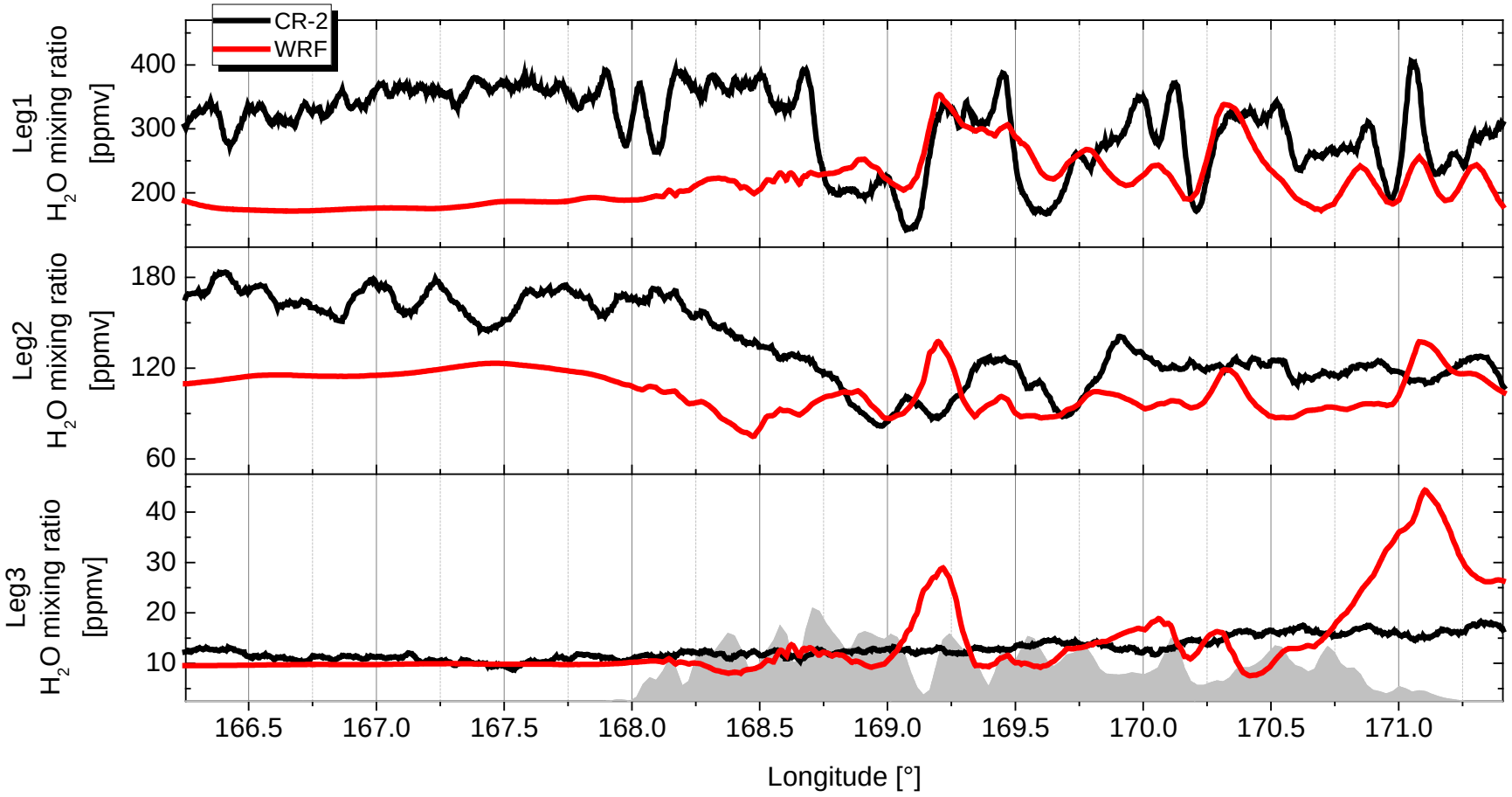
Comparison with WRF

WRF simulation:
Johannes Wagner



- WRF: gravity wave structure in all flight legs
- Qualitative agreement between simulation and in-situ measurement for the first leg

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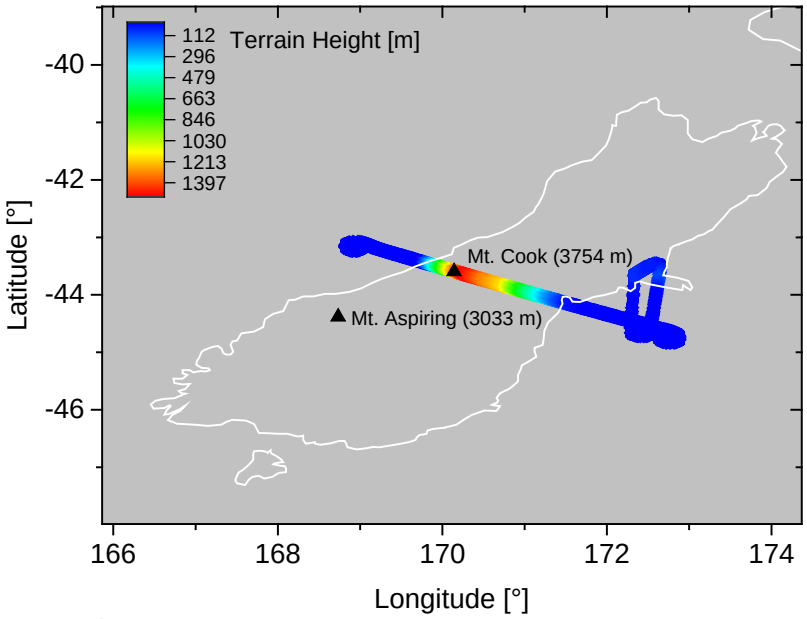
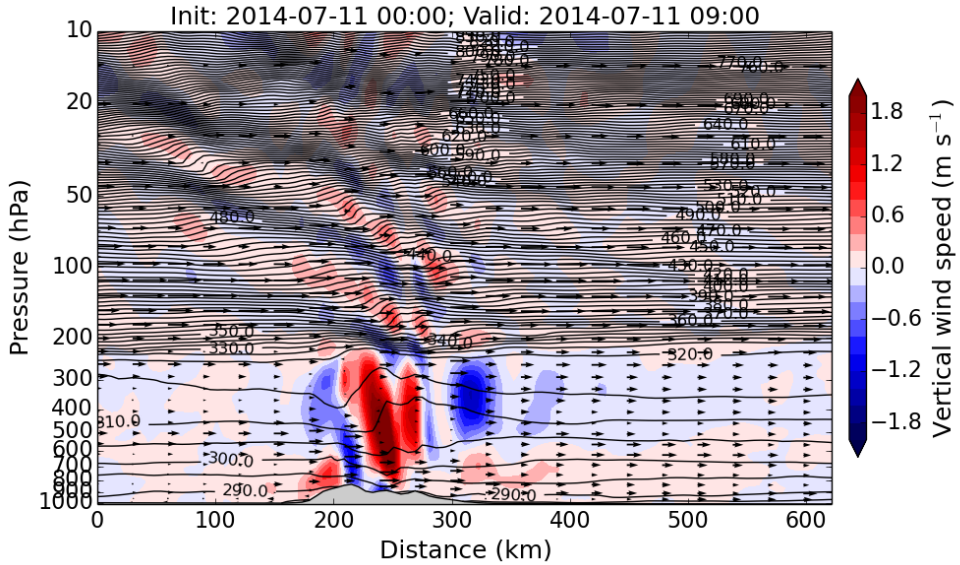
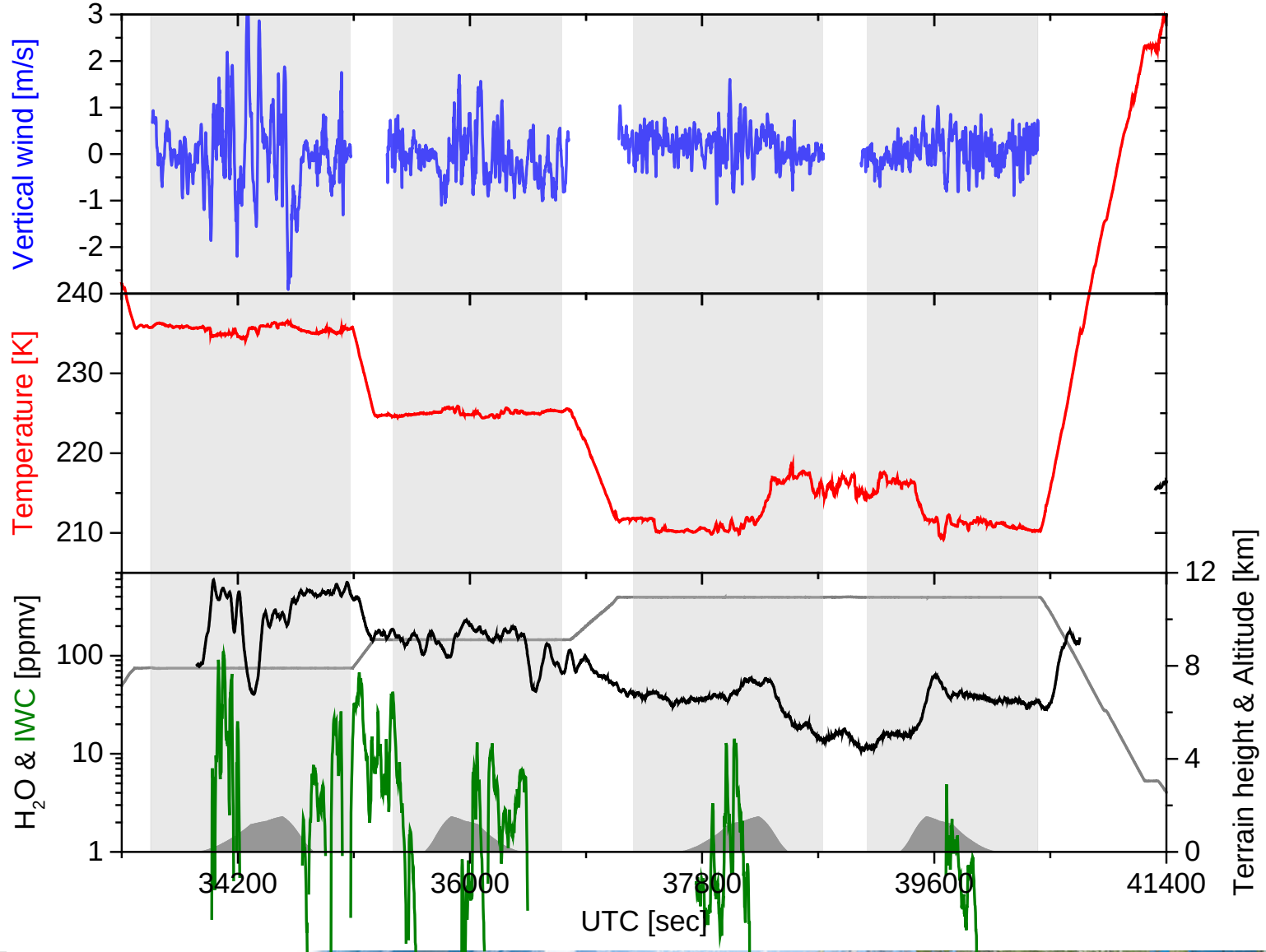
Leewave Cirrus formation

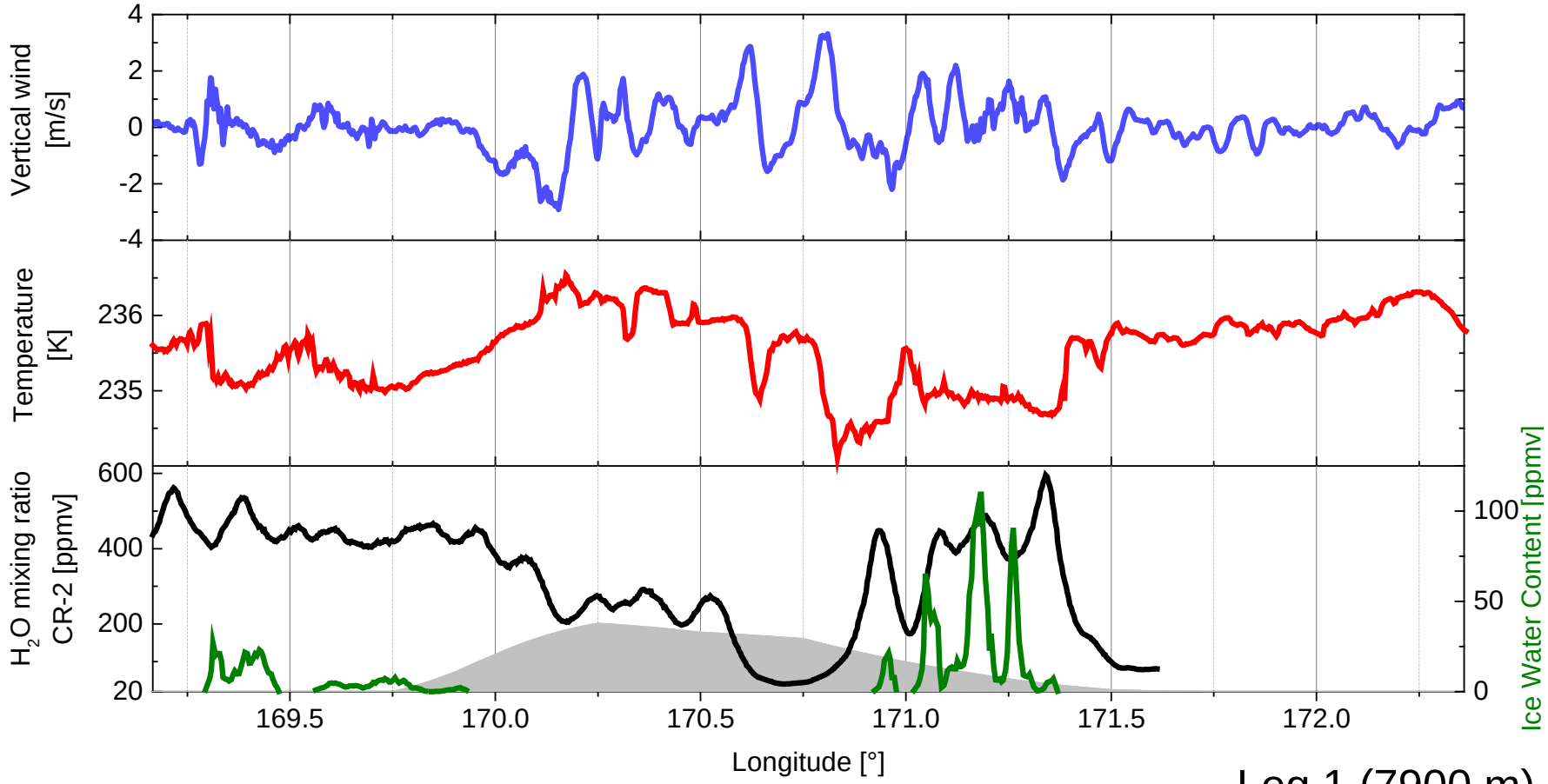
- IOP 13, flight F08 on 11 July 2014
- Strong northwesterly winds (N, NW @ 300 hPa)
- Strong mountain wave activity predicted
- Mt. Cook transect
- Example for orographically induced cirrus clouds





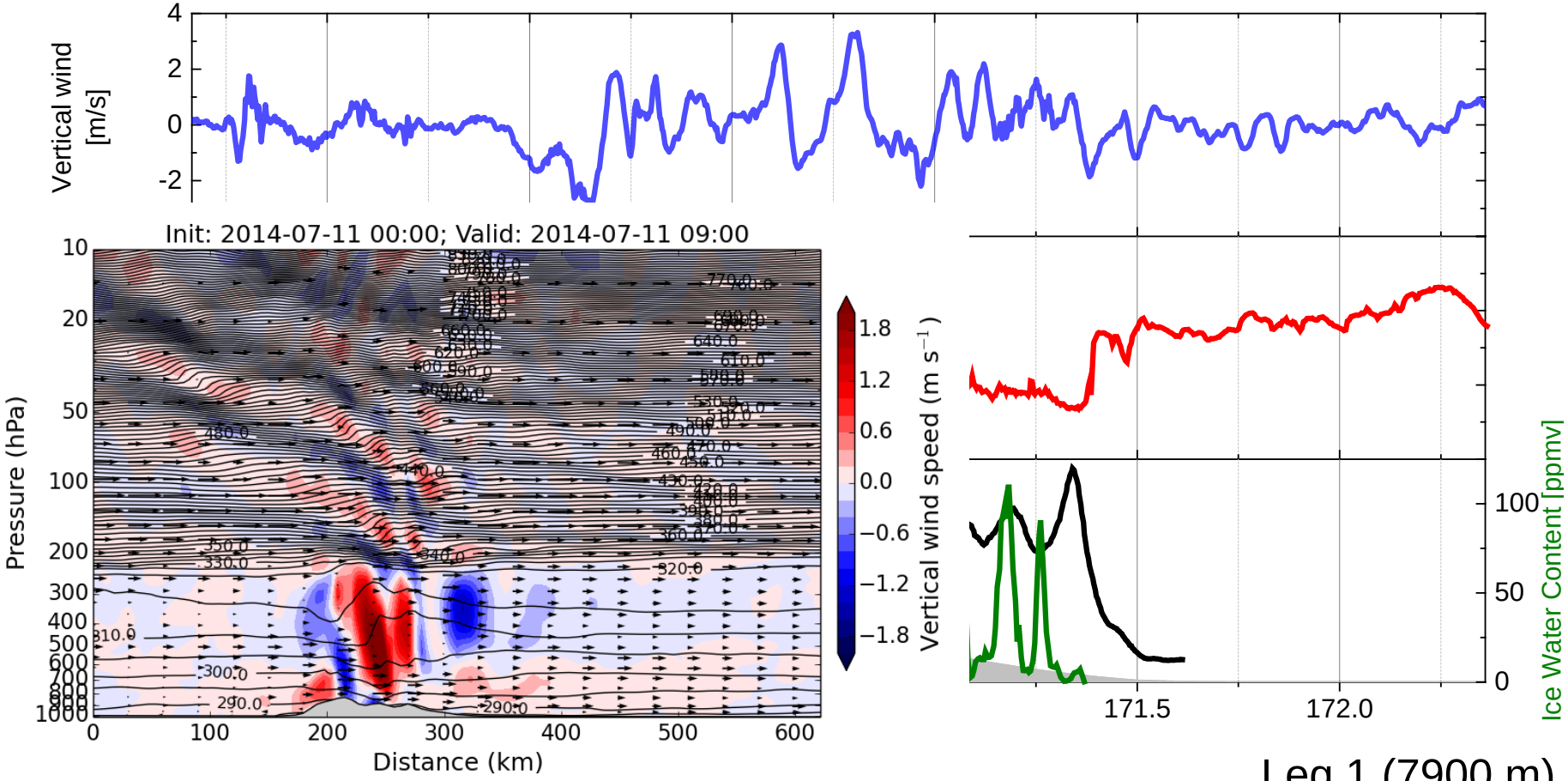
H_2O, Temperature & Wind @ flight 140711b





Leg 1 (7900 m)

- Humidity decreases initially -> downward motion?
- Lee: tropospheric air with cirrus clouds



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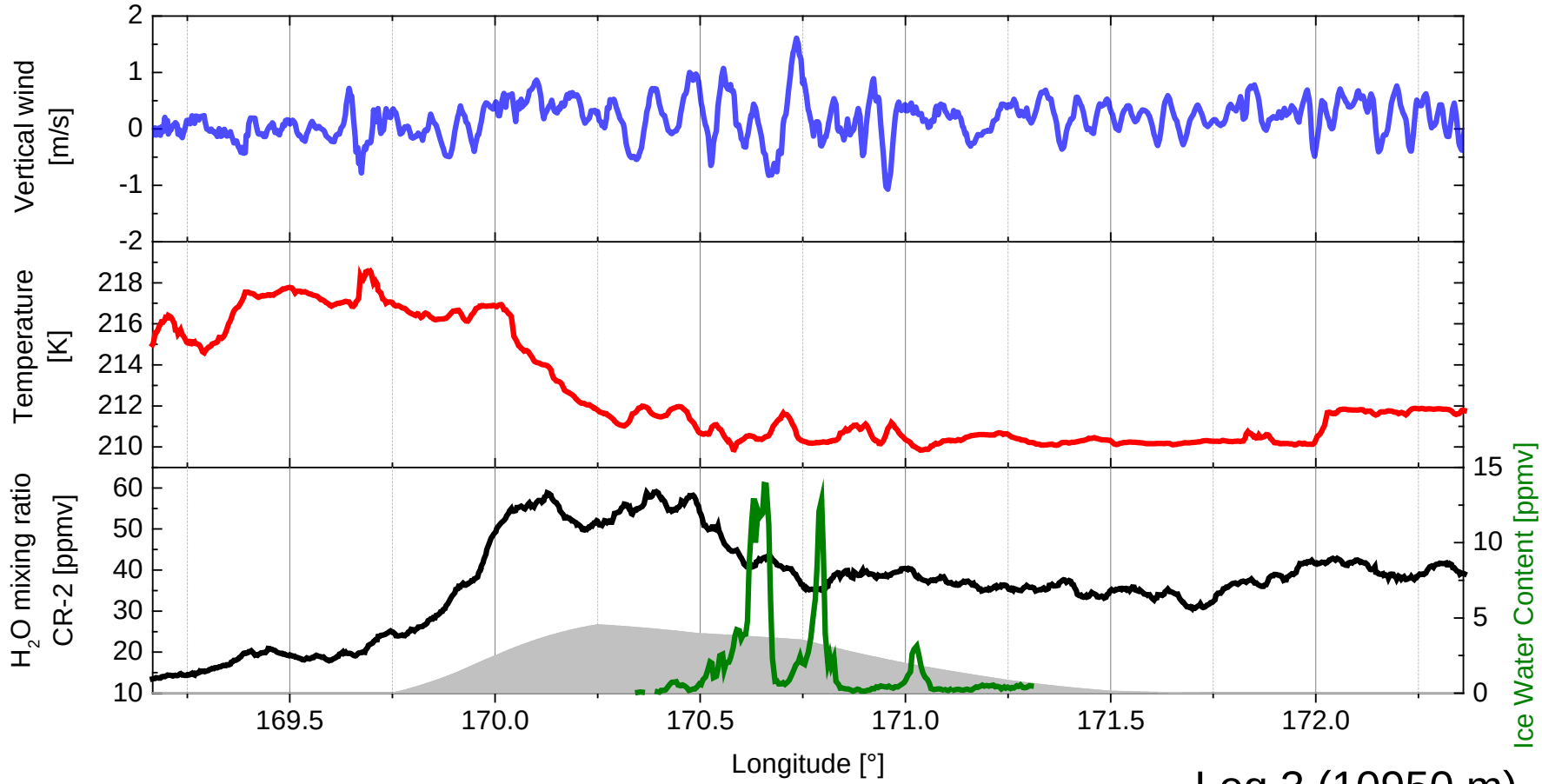
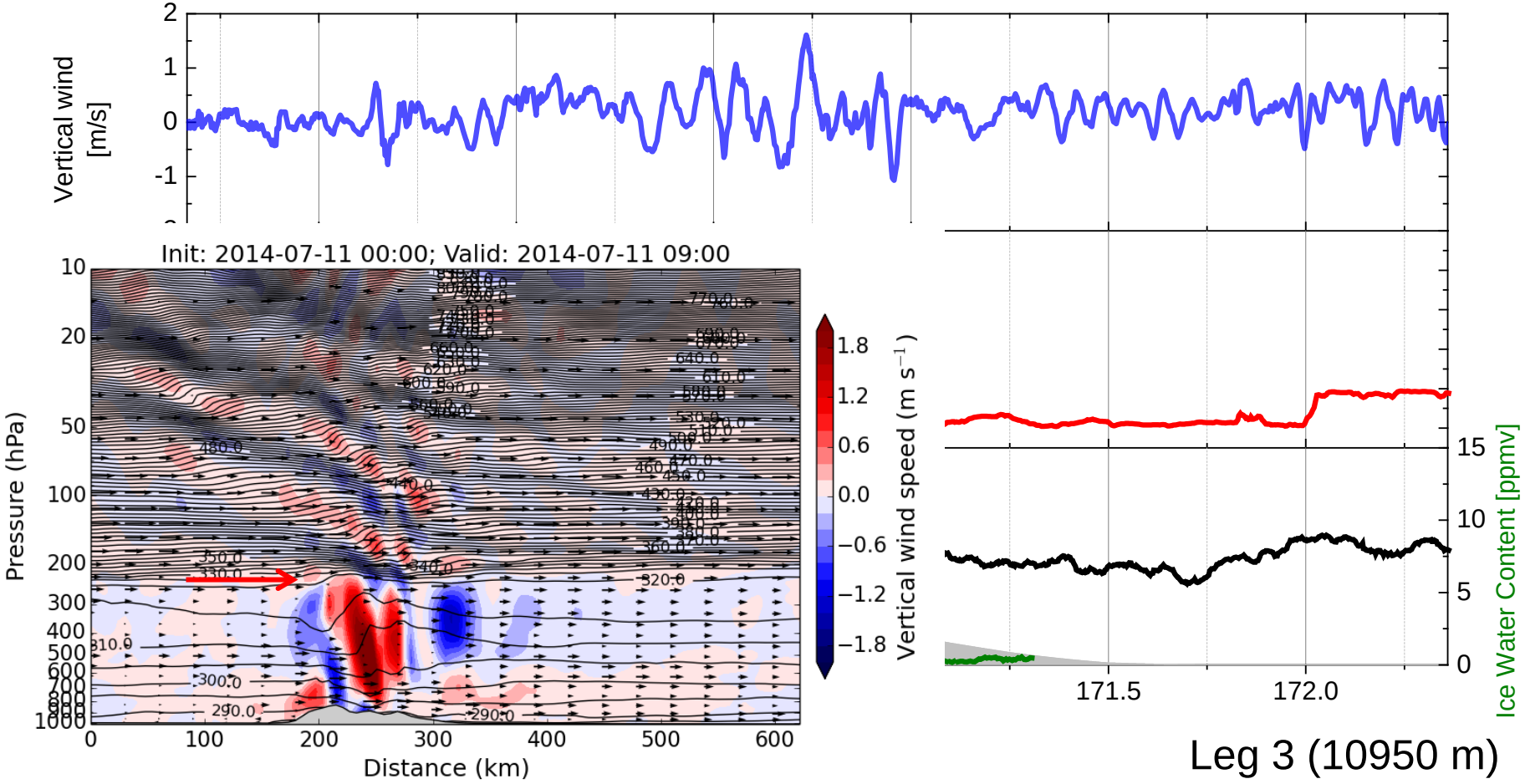


Leg 3 (10950 m)

- Luv of the Alps: stratospheric air masses
- Lee: (more) tropospheric air with cirrus clouds



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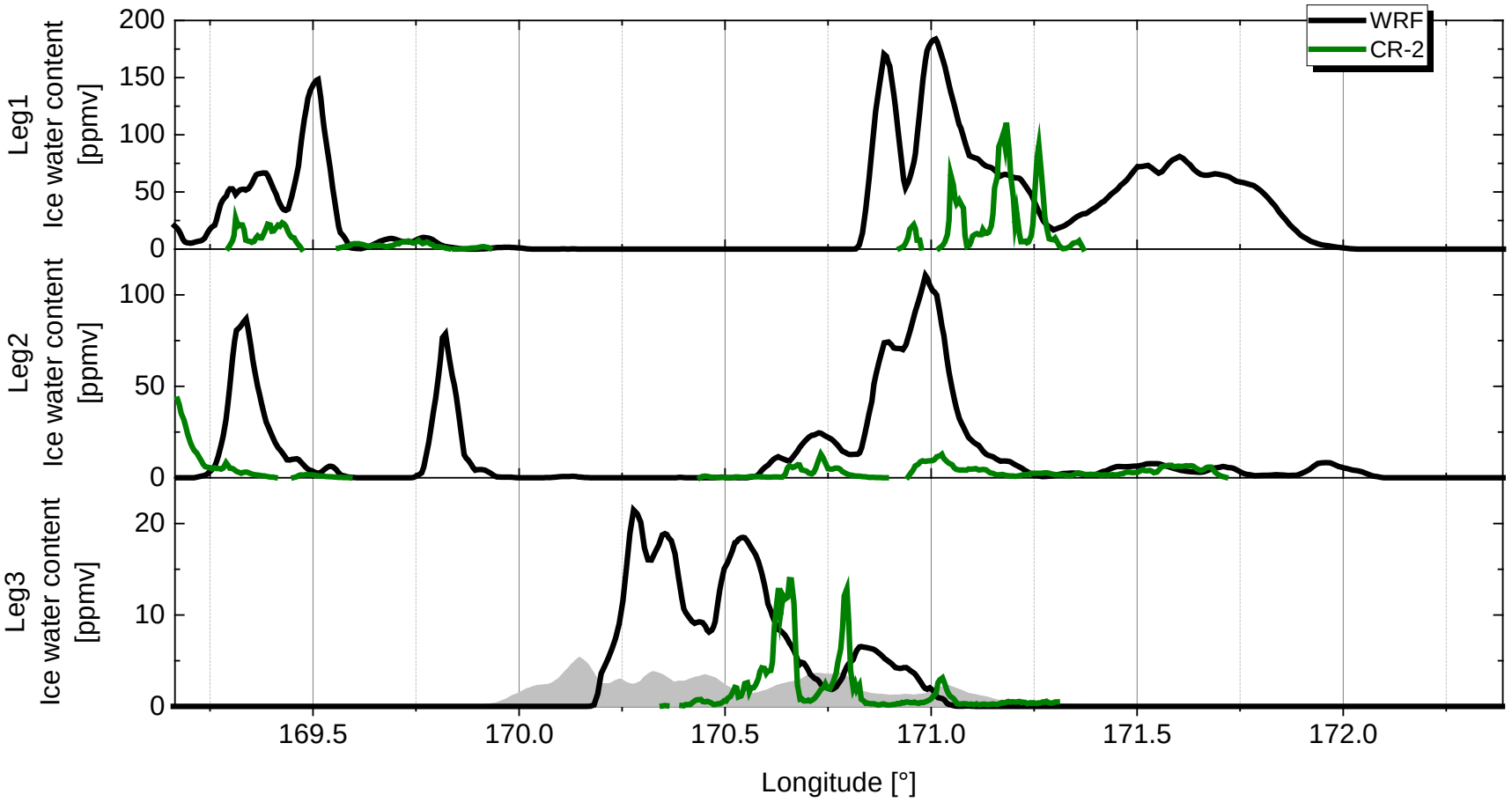
IWC comparison with WRF



- Similar cloud structures in simulation and measurement
- Spatial differences and higher IWC in WRF

Summary + Outlook

Gravity Waves

- Water vapor is a good tracer for gravity waves in the troposphere
- wave structure in different flight legs
- Qualitative agreement with WRF simulations
- Stratosphere: signature of GWs less significant → interpretation difficult due to instrument specifications

- ➢ Stratosphere-Troposphere-Exchange (Ozone as tracer in stratosphere possible)
- ➢ Water vapor fluxes in troposphere and for STE
- ➢ Comparisons with 2µ-Wind-LIDAR

Leewave cirrus

- Orographically induced cirrus clouds @ 5 research flights (140629a, 140711a+b, 140712a+b)
- Wave pattern in clouds is detectable

- ➢ Trajectory simulations to determine updraft and origin of the air mass
- ➢ Comparison with leewave cirrus at ML-CIRRUS campaign (March/April 2014)
- ➢ Comparison with ECMWF