

Improving mountain weather forecasts using TEAMx-UK observations



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Outline

TEAMx: 2025 International field programme focused on observing atmospheric processes in complex Alpine terrain at multiple scales

TEAMx-UK (2024-2028):

- FAAM aircraft measurements
 - Ground-based observations
 - Data analysis – early insights
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- Focus on Met Office UM evaluation and forecast improvements
 - Decade since high-resolution UM has been evaluated in mountainous terrain – several new dynamical and physics updates
 - Q. Are ABL and surface exchange parametrisations ok for MoBL?

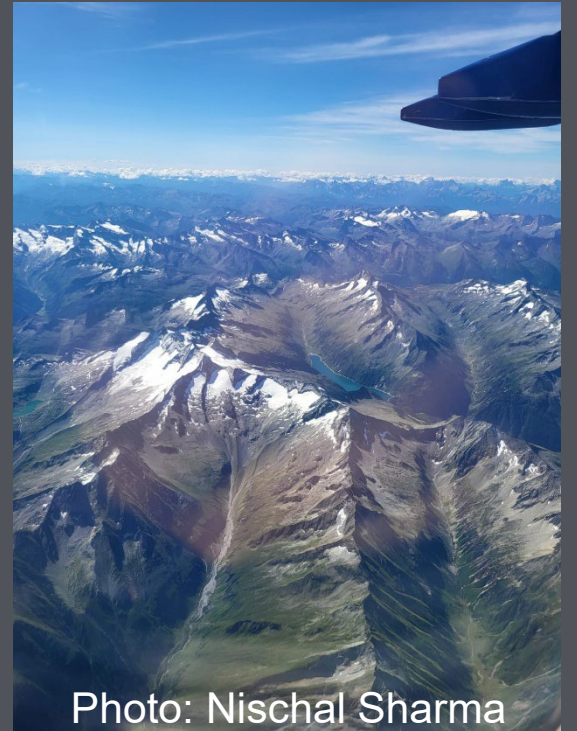


Photo: Nischal Sharma

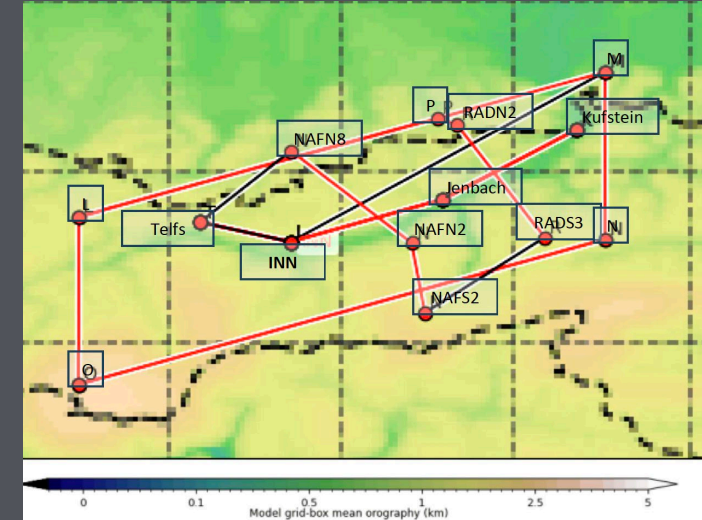
FAAM Campaign



- 27 flights over 4 weeks, 85 flying hours, average flight duration 3hrs
- Altitude 250m to 6km
- Data recorded at typically 1Hz or 32 Hz (equivalent to 100 & 3m)
- In-situ: T, q, p, u, v, w, turbulence, radiation, cloud microphysics
- Remote sensing: aerosol lidar
- Drosondes (over Austria)

Flight Coordination

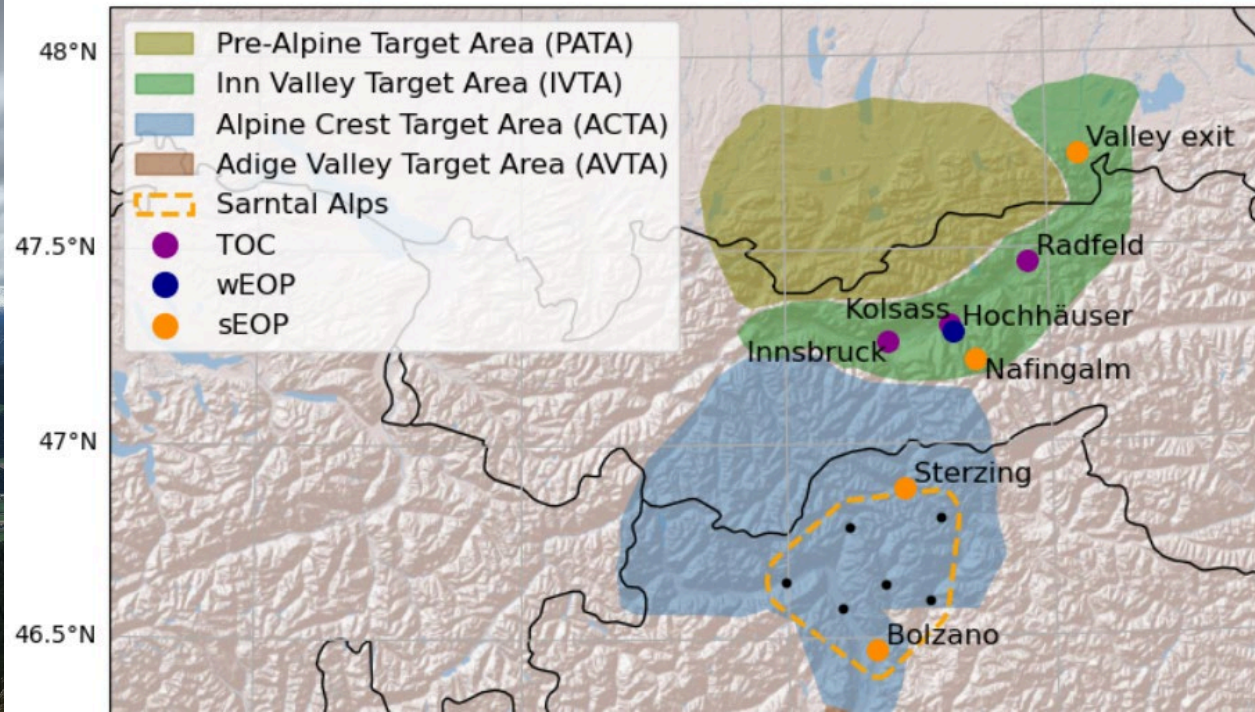
IOP Date	FAAM Flights	FAAM Air Time	Other Aircraft Coordination
11 July	C423, C424	07:31–15:47	DLR, TUBS
13 July	C425, C426	07:59–16:24	DLR, TUBS
15 July	C427, C428	08:12–16:48	DLR
18 July	C429, C430	07:59–15:56	DLR, TUBS
20 July	C433, C434	07:55–16:01	DLR, TUBS



- 6 flights with overlapping observations from all 3 aircraft

Sterzing Ground Site

- Sterzing site hosts in-situ and remote sensing instruments capturing surface fluxes, clouds, and atmospheric thermodynamics
 - wEOP (20/01/2025 to 28/02/2025)
 - sEOP (16/06/2025 to 25/07/2025)
- Data available via JASMIN and CEDA



Sterzing Measurements

In-situ

- Flux tower sonic anemometers (3D turbulence)
- Surface energy balance (R_n , H, LE, G)

Remote sensing

- Lidars (profiles u, v, w, σ_w)
- Radiometer (profiles T, q)
- Ceilometer (profiles aerosol)
- Sun photometer (AOD)
- Microwave rain radar (precip)

Radiosondes

- 127 radiosondes (wEOP), inc 31 pairs (3-hourly profiles u, v, w, T, q, p)
- 190 radiosondes (sEOP)



Science Themes

Model bias: orographic precipitation, near surface winds, surface fluxes, temperatures (valley & and mountain tops), fog formation and dissipation

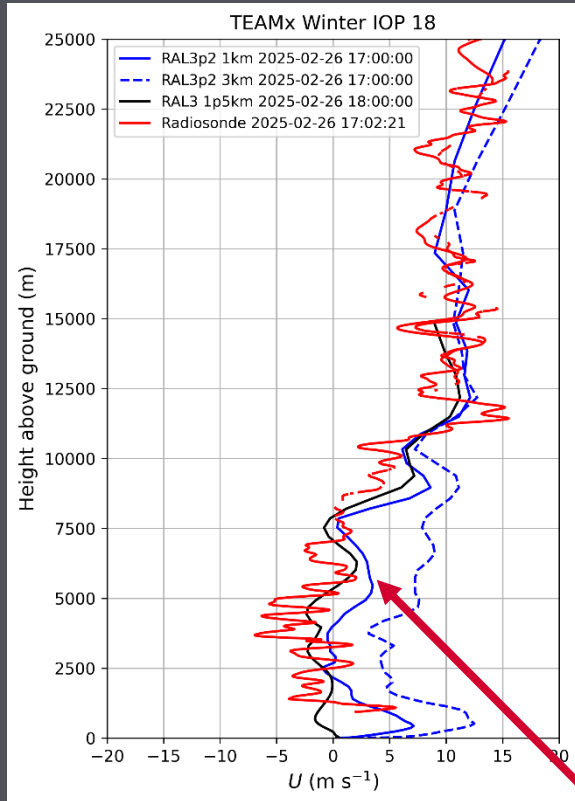
- Orographic gravity waves
- Orographic convection
- Mountain boundary layer turbulence
- Orographic flows (foehn wind, slope winds, valley winds)



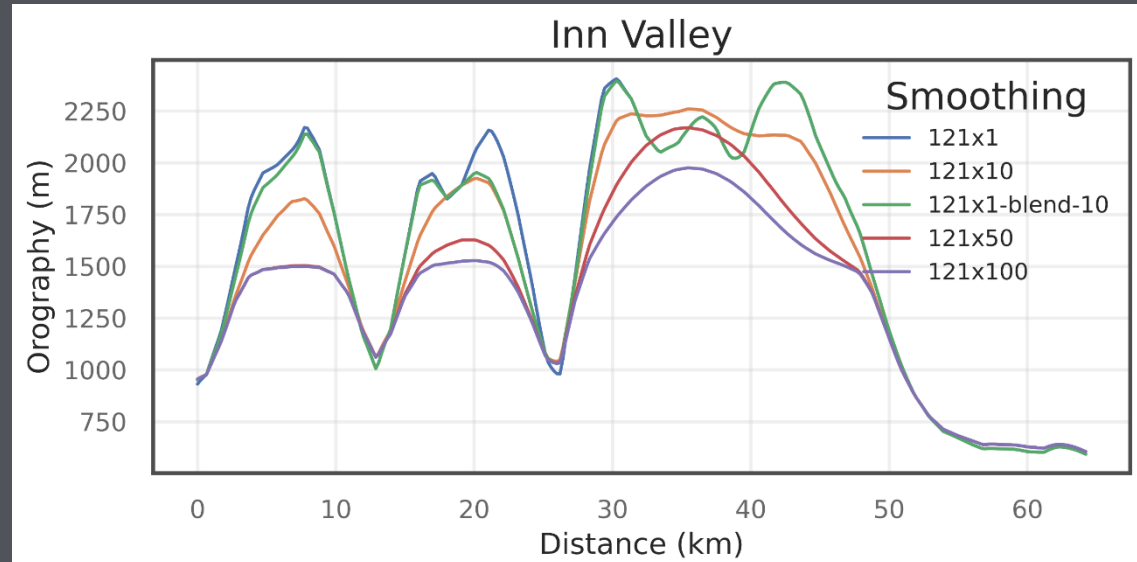
Model Orography and Resolution

Siddarth Gumber (BAS)

- Terrain representation in models affects turbulence, convection, gravity waves and flow structure
- Higher horizontal resolution and realistic orography improve weather prediction accuracy



Radiosonde u-wind profile
Winter IOP 18 17:00 UTC



Cross-section of UM
1km orography
through the Inn Valley

- 1-2-1 smoothed orography used to ensure numerical stability
- 10, 50 & 100 times smoothing removes details
- Targeted smoothing retains detail but is numerically stable
- Increasing horizontal resolution improves profiles of windspeed

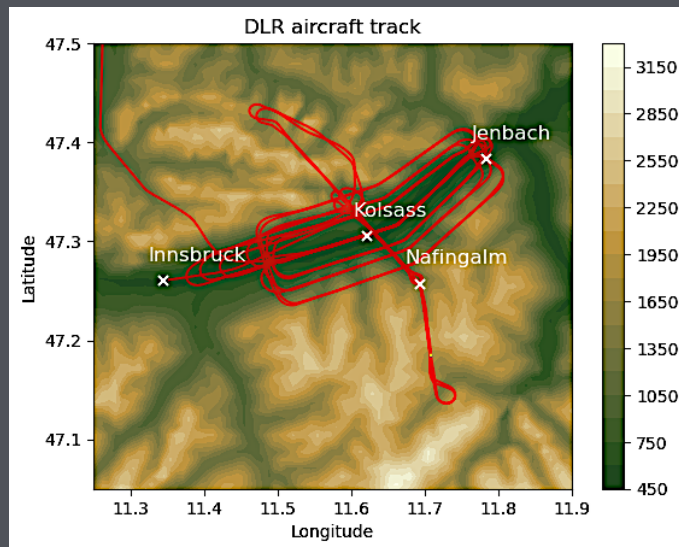
Valley Turbulence Intensity Variability

Jack Mustafa, Dan Smith (U. EA)

- Orographic flows in Alpine valleys result from interactions between the large-scale winds, valley shape, and thermal effects

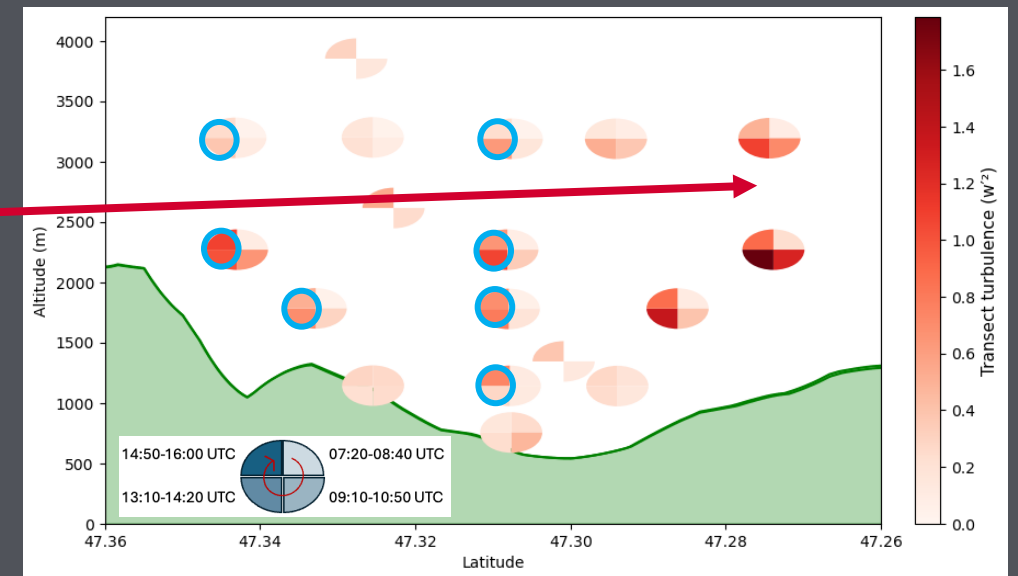
Focusing on aircraft observations from the Inn Valley on 20th July 2025:

- 6 research flights on this date allow broad spatiotemporal understanding,
- Complex interacting phenomena: southerly Foehn, up-valley winds and cold pooling



Plan view of an aircraft track to the east of Innsbruck.

- Strong turbulence on south of valley caused by Foehn winds
- Stronger turbulence in afternoon as up-valley wind develops

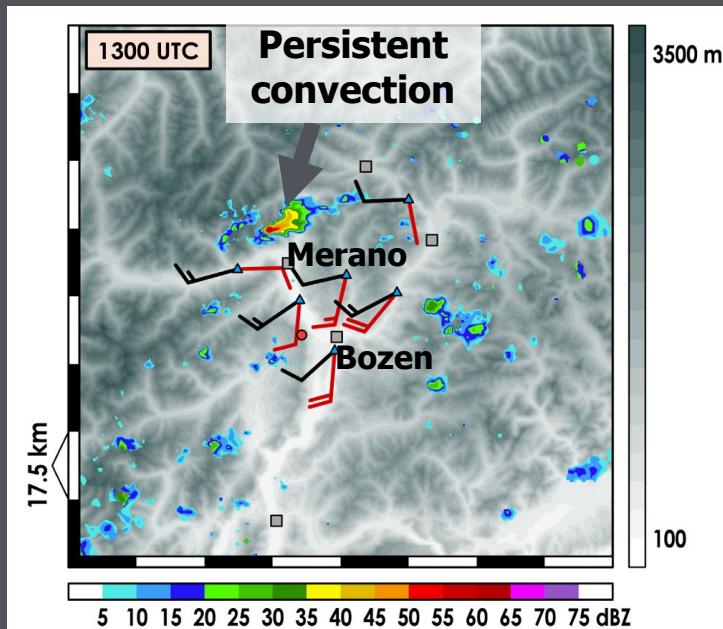


Spatiotemporal pattern of vertical velocity variance of along-valley transects on 20th July 2025

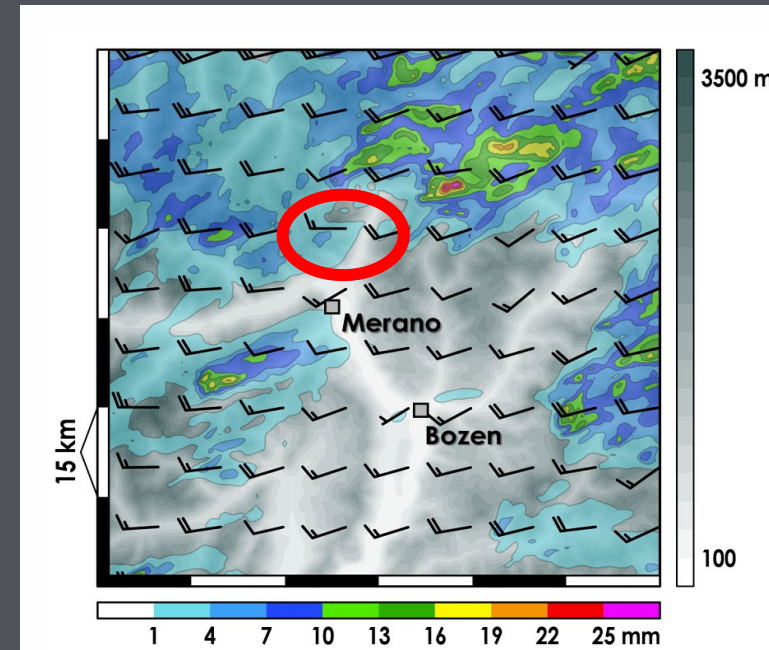
Orographic Convection

Kyle Ahern (U. Leeds)

- Orographic convection events often are underestimated or missed by models, impacting heavy rainfall and flood predictions
- Summer 1OP-22: Persistent orographic convection occurred near Merano, which was not seen in 1-day forecasts. Q. Is this tied to model valley flows and moisture south of Merano?



1300 UTC 23 July 2025 3-km reflectivity (colour), orography (grayscale). Ground KITcubes (triangles). Red and black barbs respectively indicate 1- and 3-km KITcube lidar winds.

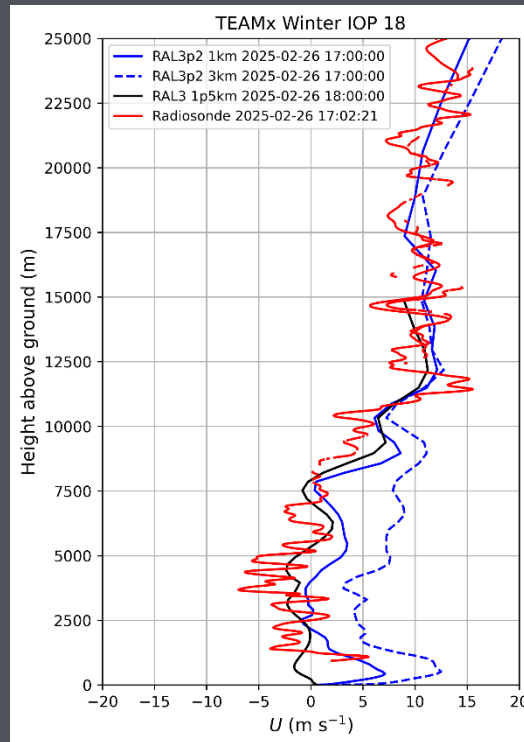


Simulated 1200–1800 UTC 23 July rainfall totals (colour), 1200 UTC 23 July 3-km wind barbs, orography (grayscale) from the 1200 UTC 22 July MetUM initialization. The approximate area of observed convection is encircled in red.

Orographic Gravity Waves

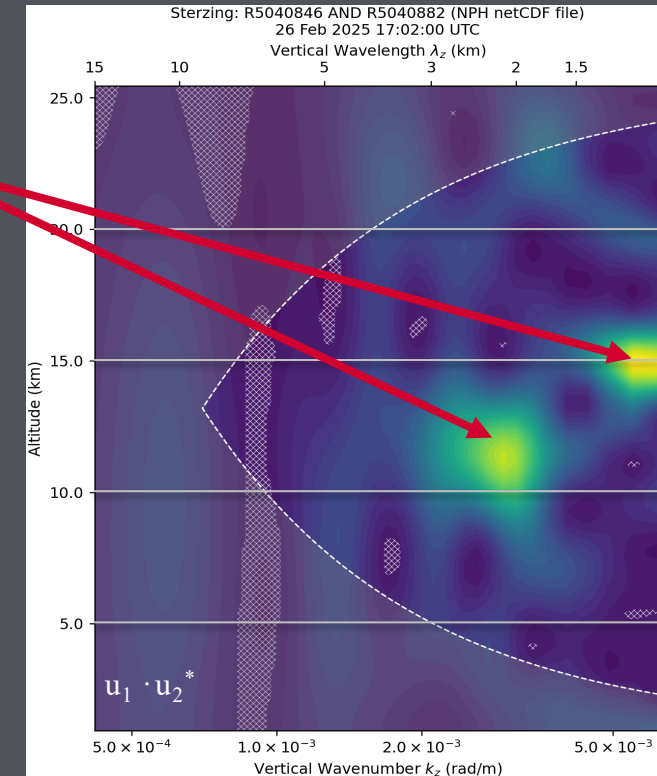
Tim Banyard (U. Bath)

- Orographic gravity waves transfer momentum & energy through atmosphere
- Dual radiosonde launches provide data on wave generation, propagation, and breaking



Radiosonde launch at 17:00 UTC 26/02/25 showing zonal and meridional wind speed for the radiosonde and three different Met-UM configurations

- Cospectral power is high = both sondes are observing the same wave at this scale
- Phase shift between sondes used to infer horizontal wavelength of gravity wave
- Measurements will be used to evaluate UM
 - Orographic gravity wave drag
 - Orographic flow blocking
 - Turbulent orographic form drag

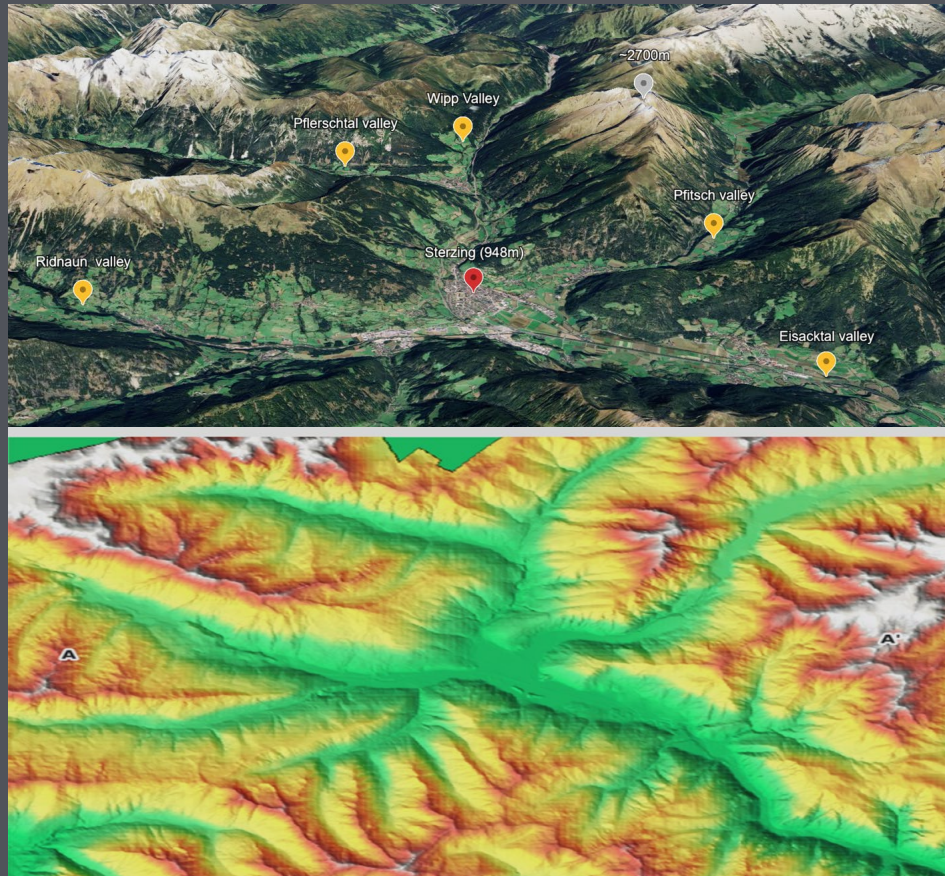


Dual radiosonde launch at 17:00 UTC on 26/02/25 showing cospectrum (with statistical significance)

Valley Turbulent Exchange

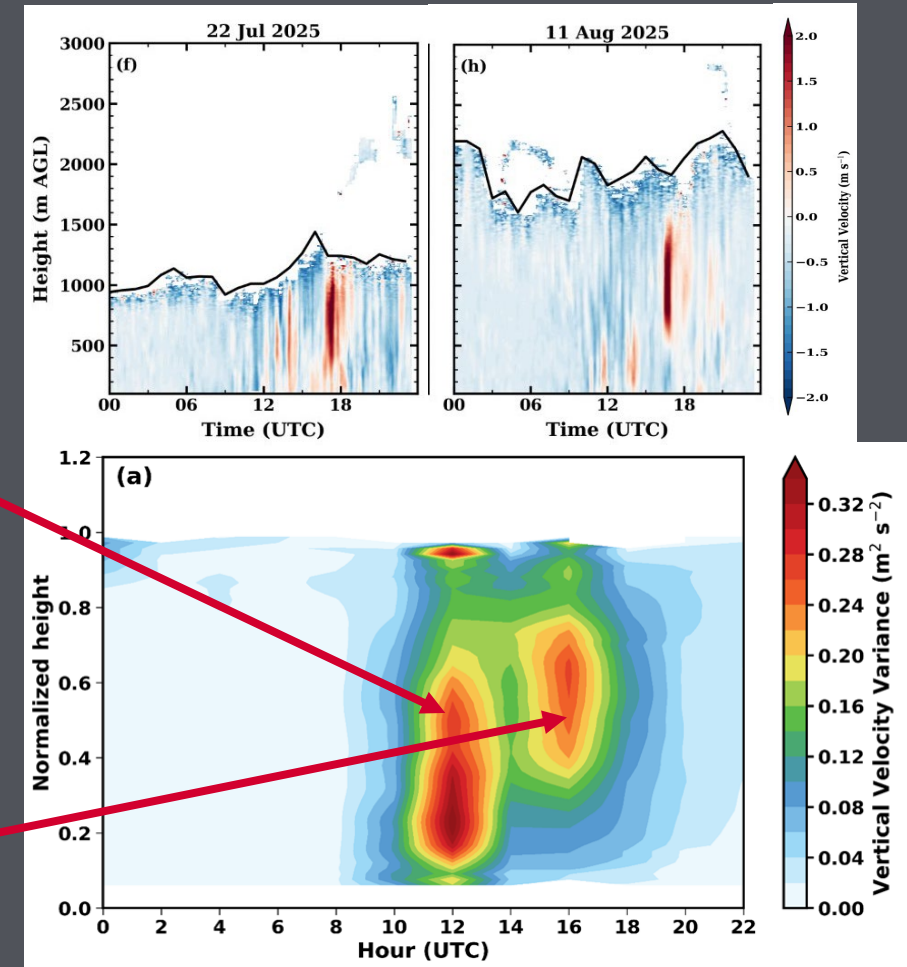
Nischal Sharma, Natalie Harvey (U. Reading)

- Valley exchange processes linked to foehn winds, valley flows, slope flows, convection
- Sterzing basin located at intersection of multiple valley systems



3-D terrain map and (b) Digital Elevation Model of the study site (Sterzing, Italy)

- Early afternoon turbulence driven by surface heating
- Late afternoon elevated turbulence above strong up-valley flow



Doppler lidar at Sterzing – (Top) Vertical velocity from 2 thermal MoBL days, (bottom) composite turbulence from 17 thermal MoBL days

Summary & Future Plans

- TEAMx measurements provide unique data capturing diverse Alpine atmospheric processes
- Multiple observation platforms to enhance data coverage in heterogeneous terrain
- TEAMx-UK datasets are openly accessible via UK archives (CEDA and Earth Data Portal), to encourage ongoing research and community collaboration

Modelling Plans

- UM simulations at 1km and 300m over Alpine region
- Testing new UM parametrisations (cloud microphysics, boundary layer turbulence, convection) and dynamics (GungHo vs EndGame)
- Inter-model comparison with UM / ICON / AROME

