



**ÖSTERREICHISCHES
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Nowcasting of orographic induced turbulence in aviation meteorology

Mag Valerie Kumer, PhD



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Turbulence forecasts not always hit the scores



WMO cloud atlas



How can we improve nowcasting turbulence ?

- ▶ **Be aware of the ingrediance**
 - ▶ prediction of wind speed/direction
 - ▶ air mass age, development and movement

- ▶ **Sense the presence of turbulence**
 - ▶ Remote sensing -> good but limited to fixed locations
 - ▶ Visual -> orographic coulds, drifting snow, waterrippels
 - ▶ Sensible -> PIREPs



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Ingredience



WMO cloud atlas



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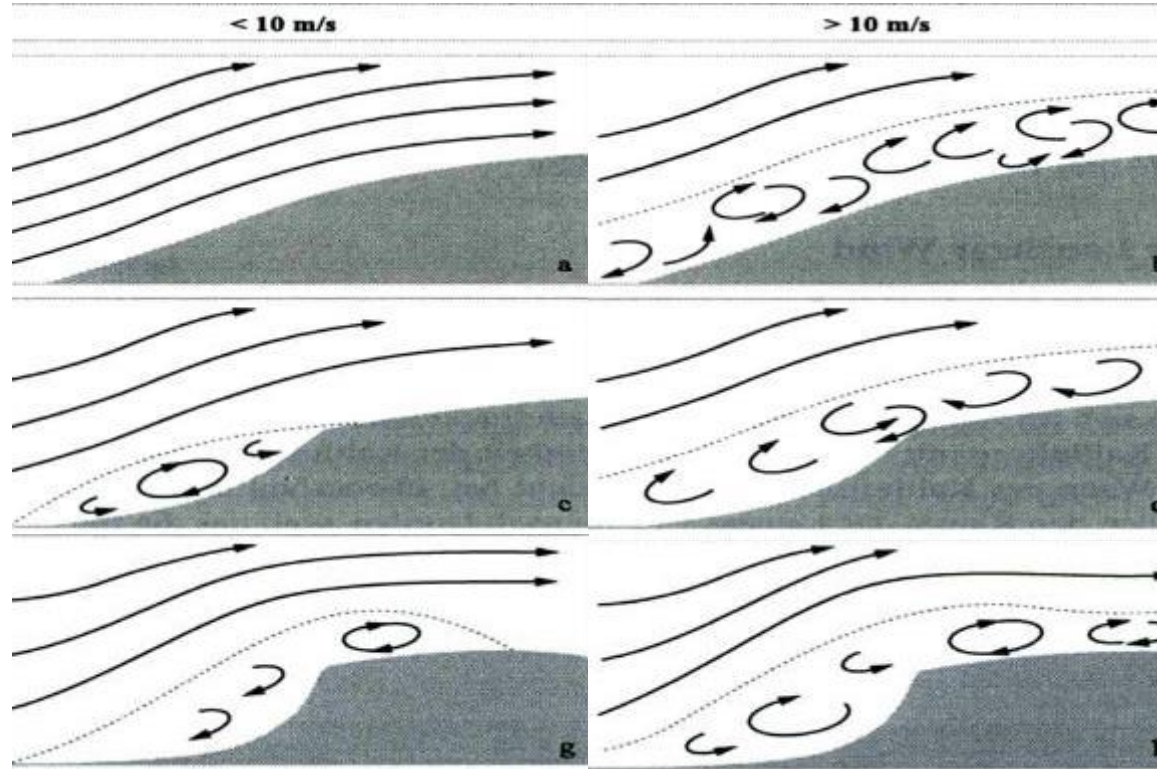
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Ingredience

► mountain shape

► wind speed

$$v = \bar{v} + v'$$





Ingredience

► mountain shape

► wind speed



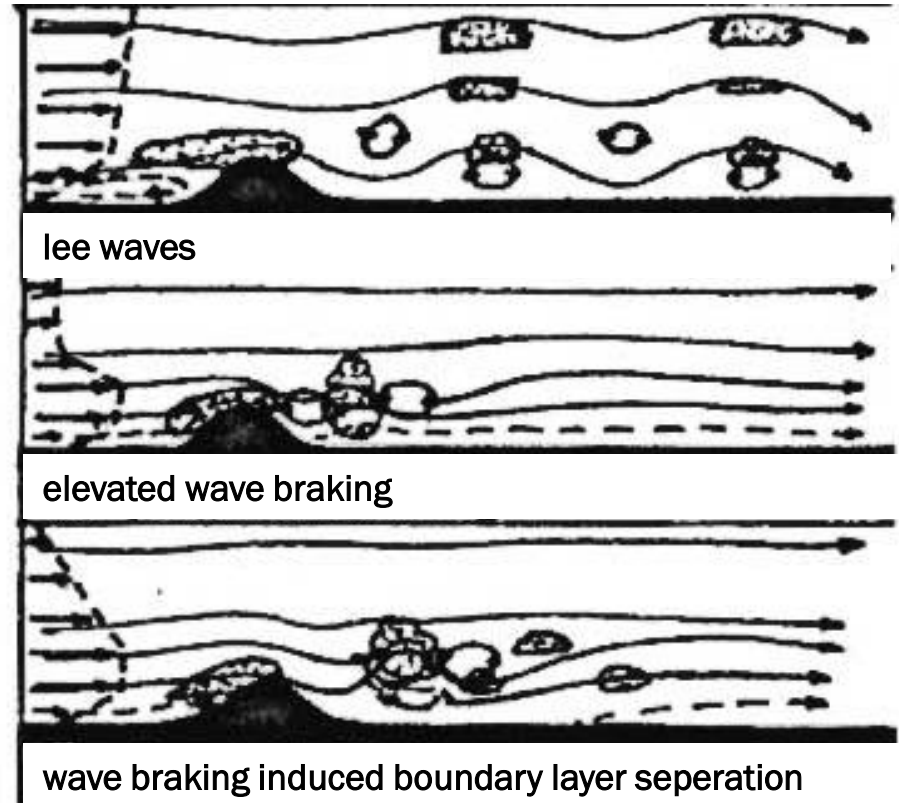
laminar flow



bluff body boundary layer separation Lorenzen 2002

Ingredience

- ▶ mountain shape
- ▶ wind speed
- ▶ atmospheric stability





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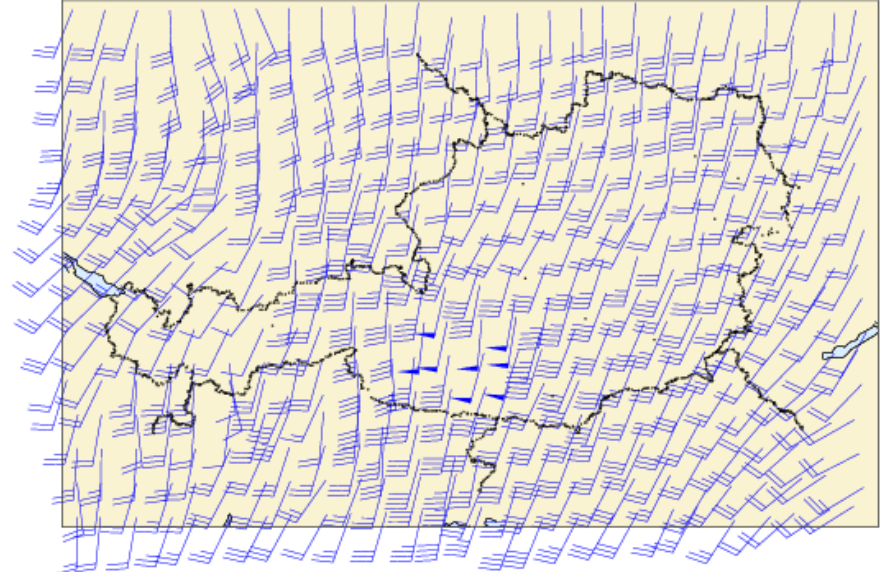
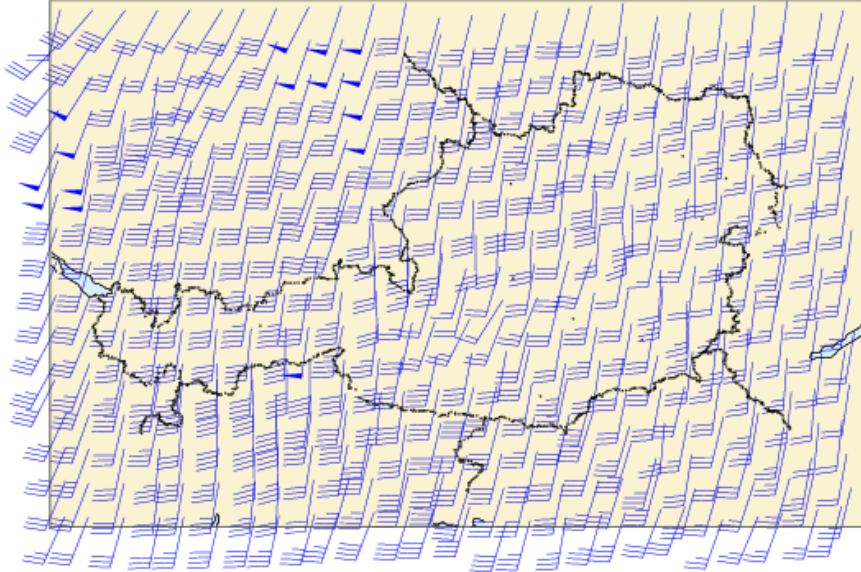
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Indicators – wind speed

500hPa 041021 12 FC Tuesday 051021 06



700hPa 041021 12 FC Tuesday 051021 06



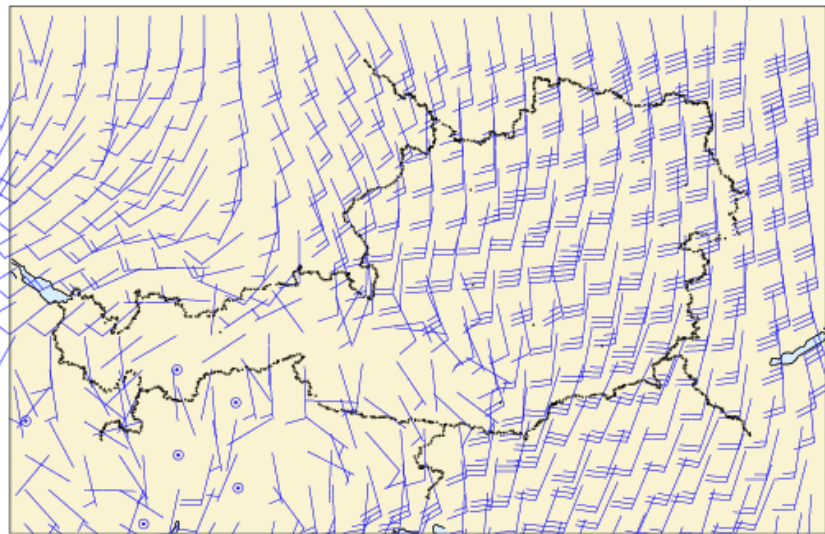


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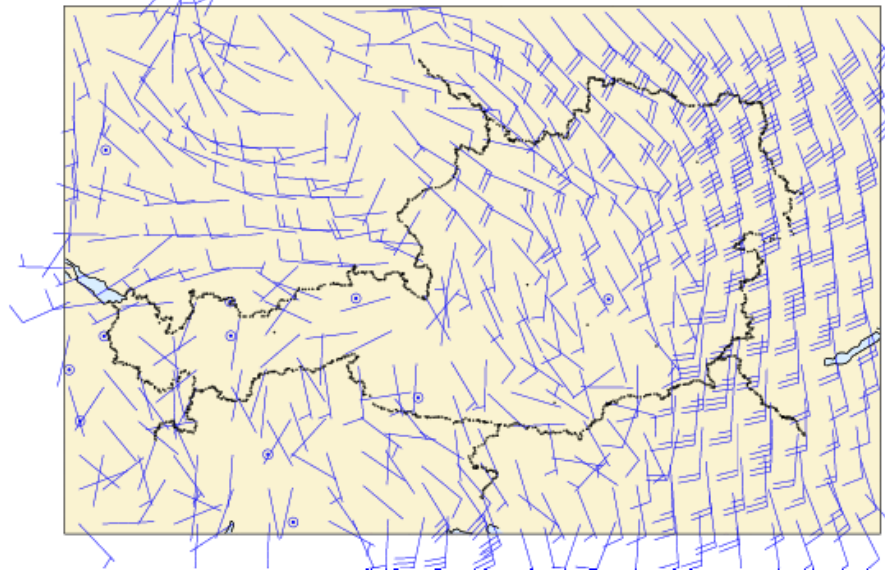
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Indicators – wind speed

850hPa 041021 12 FC Tuesday 051021 06



925hPa 041021 12 FC Tuesday 051021 06

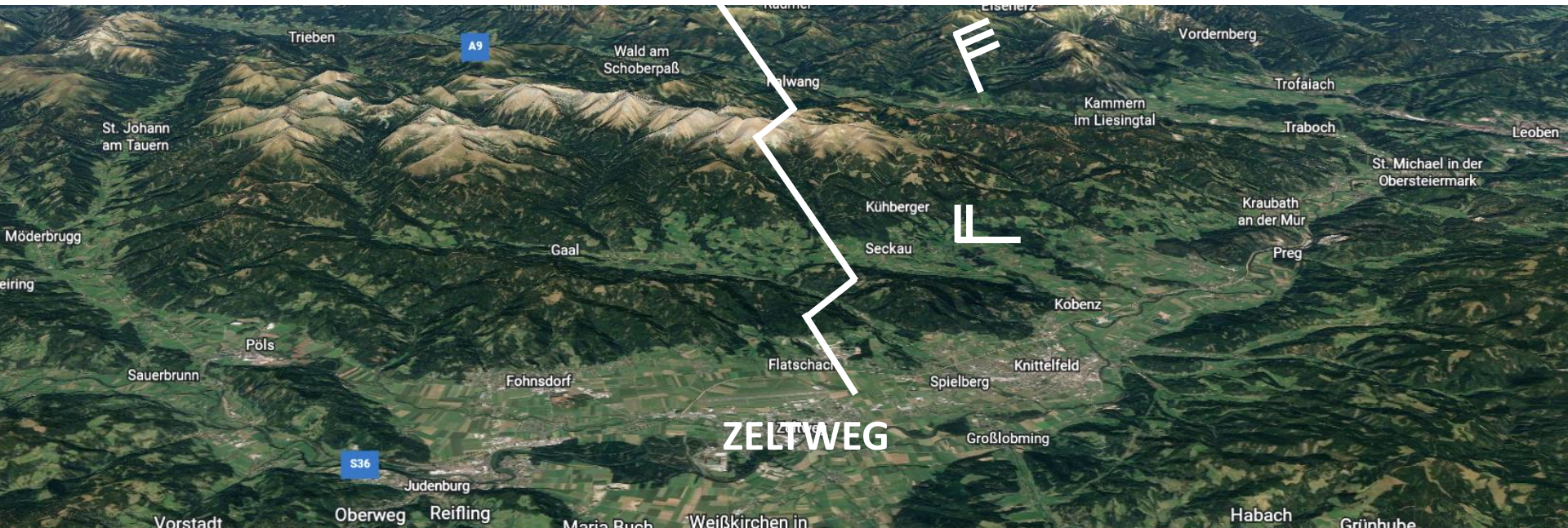




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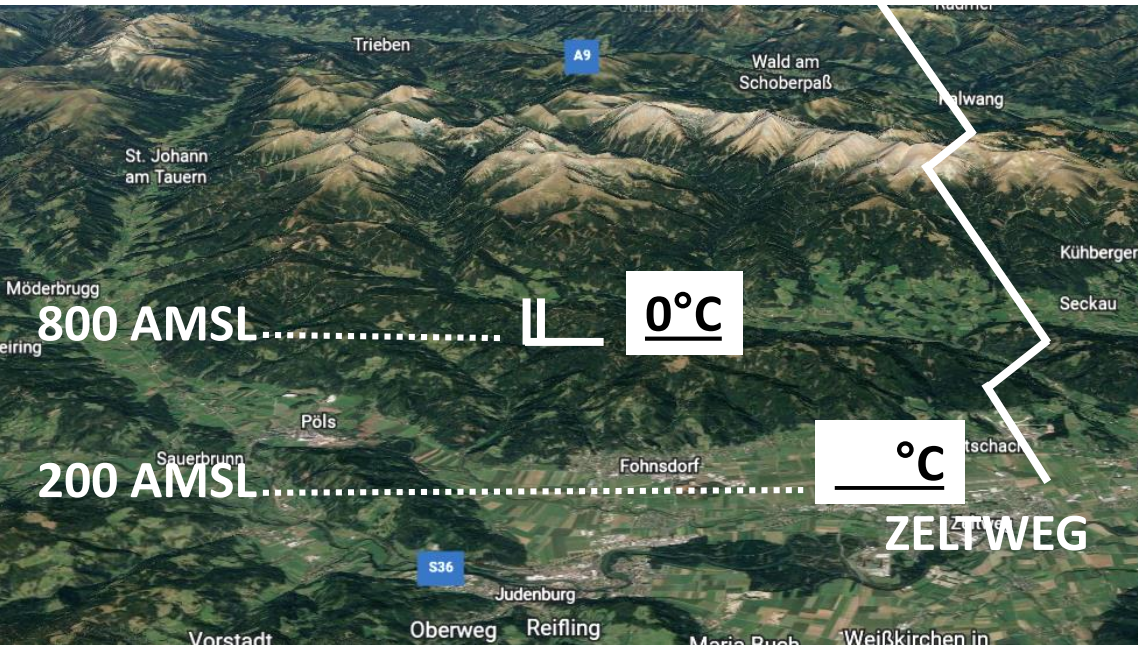
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Indicators – inversions





Indicators – onset



chat waterfall:

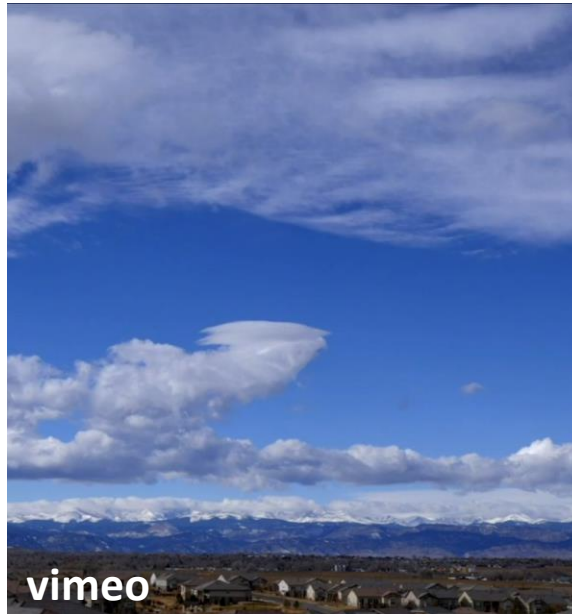
1. Read the question:
2. “What temperature must be prevailing in Zeltweg so that gusts of 20 kt measured at the mountain station reach the valley bottom?”
3. Type your answer in the chat window.
4. On the count of 3 hit the enter button



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Indicators – orographic clouds



Mag Valerie Kumer, PhD



Indicators – orographic clouds

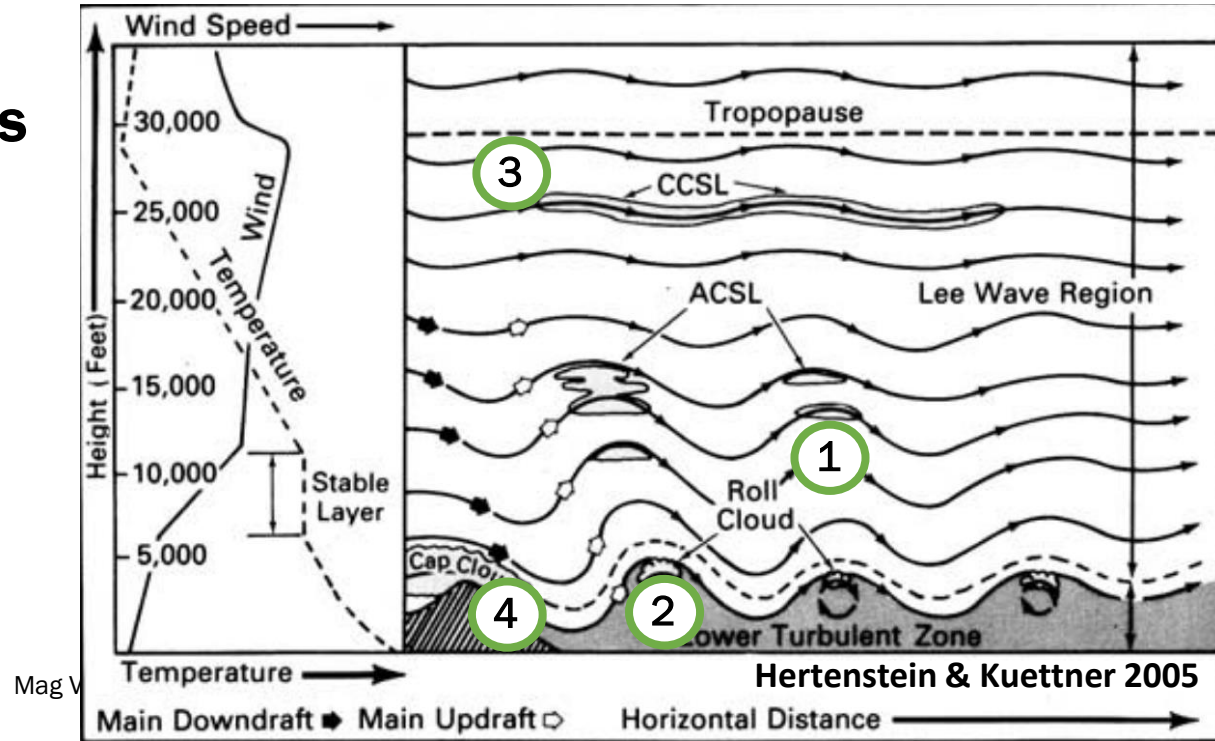
► Orographic clouds

1 lee wave

2 rotor

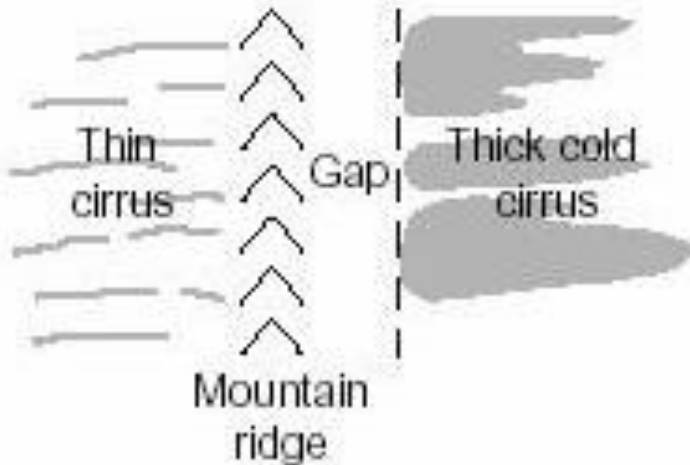
3 gravity wave

4 downslope wind

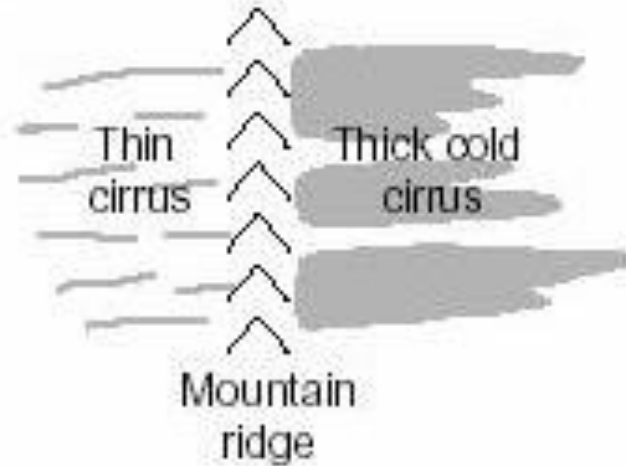


Indicators – orographic clouds

(a) Turbulent lee waves



(b) Non-turbulent lee waves





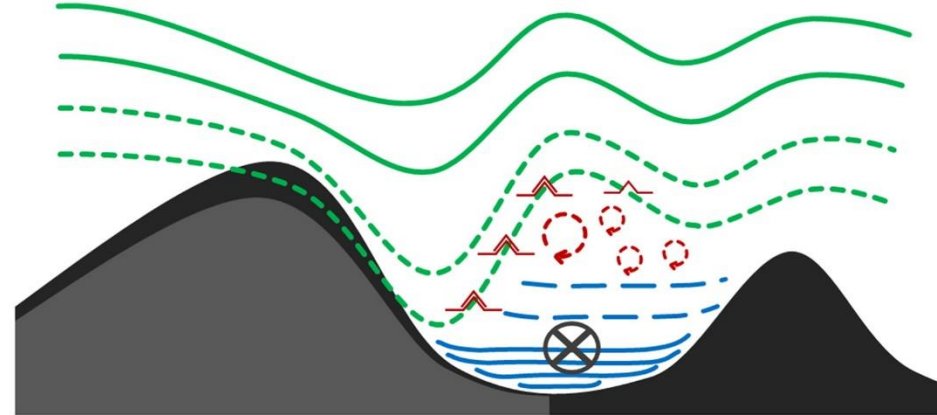
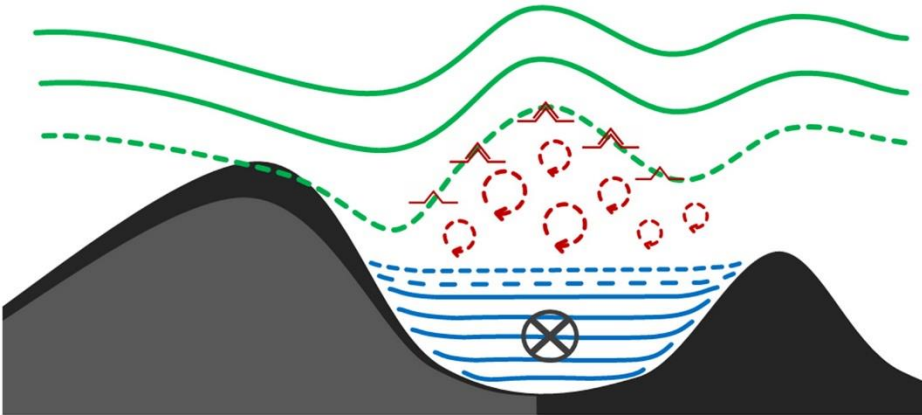
VIDEO: https://www.youtube.com/watch?v=t_tG8y6uLJw

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Indicators – inversions

— laminar - - - - - turbulent (X) valley wind — temperatur



Strauss, 2016

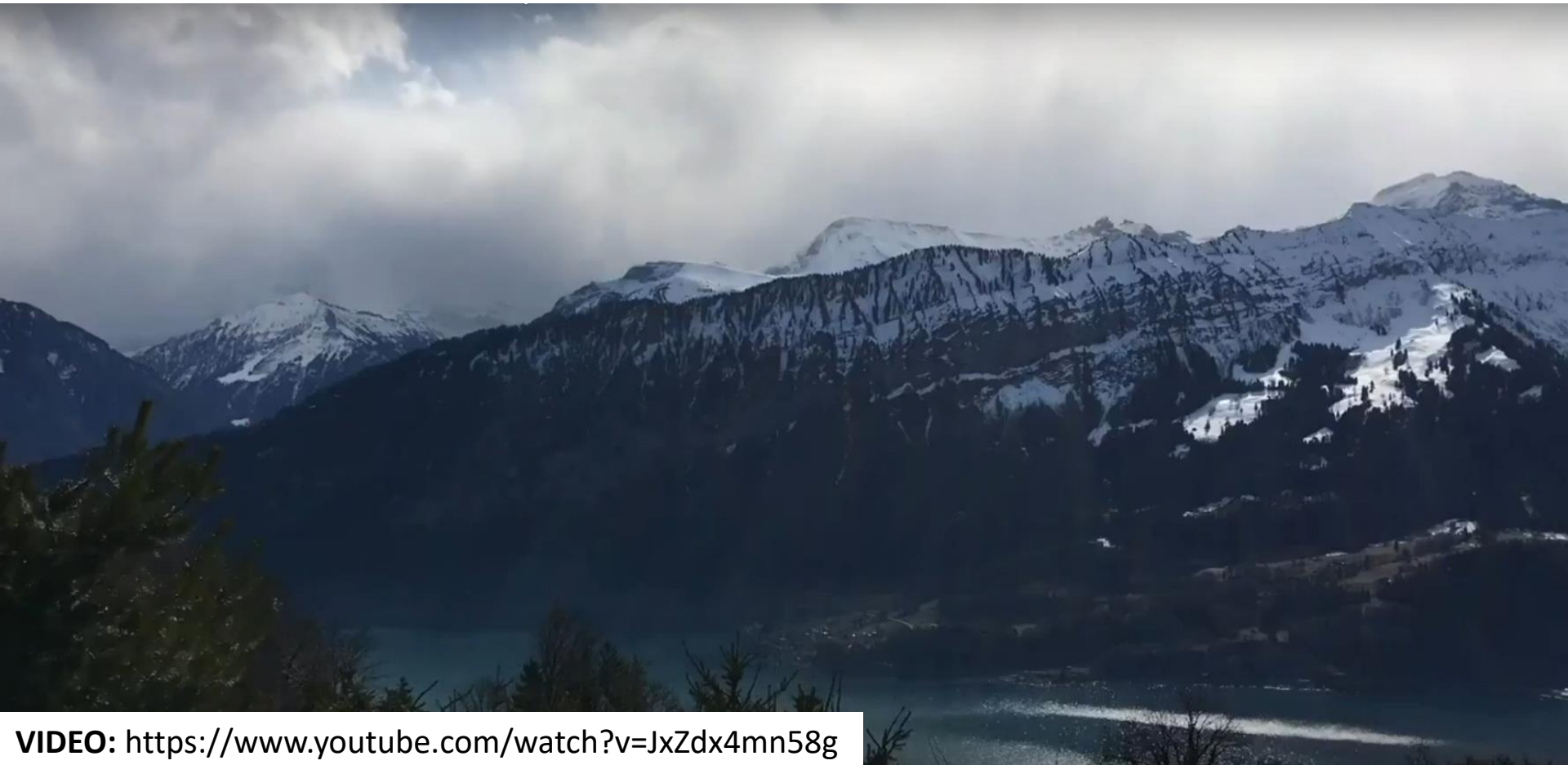
(a) Scenario A

(b) Scenario B

chat waterfall:

1. Read the question:
2. “What feature in this image shows that gusts reach the valley bottom this time?”
3. Type your answer in the chat window.
4. On the count of 3 hit the enter button

VIDEO: <https://www.youtube.com/watch?v=JxZdx4mn58g>

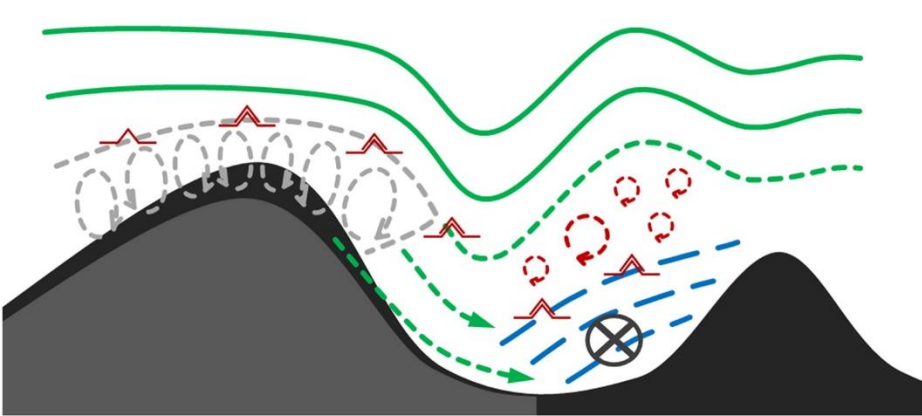


VIDEO: <https://www.youtube.com/watch?v=JxZdx4mn58g>



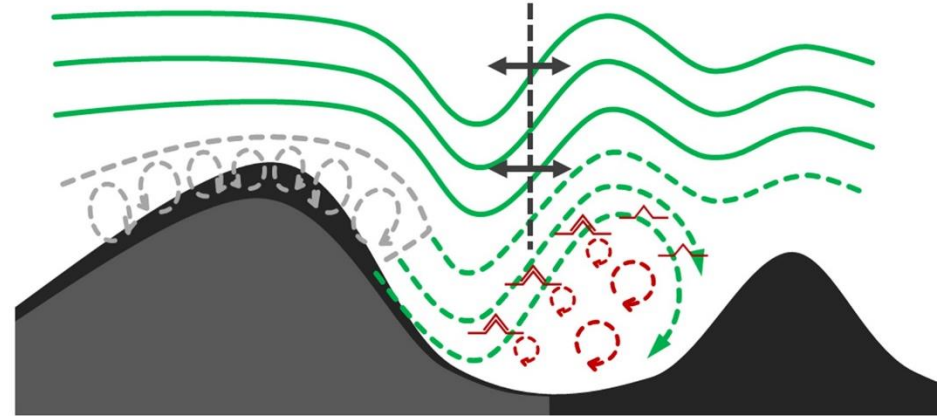
Indicators – inversions

— laminar - - - - - turbulent (X) valley wind — temperatur - - - - - cap cloud



Strauss, 2016

(c) Scenario C



(d) Scenario D



How can we sense turbulence?

► ICAO definition of turbulence

► LIGHT TURB

- Effects are less than those of moderate intensity

► MODERATE TURB

- There may be moderate changes in aircraft attitude and/or height but the aircraft remains in control at all times.
- Air speed variations are usually small.
- Changes in accelerometer readings of 0.5-1.0g
- Loose objects move about.



How can we sense turbulence?

► ICAO definition of turbulence

► SEVER TURB

- Abrupt changes in aircraft attitude and/or height. The aircraft may be out of control for short periods
- Air speed variations are usually large
- Changes in accelerometer readings greater than 1.0g (civil), +4g/-2g (military)
- Loose objects are tossed about

► EXTREM TURB

- Effects are more pronounced than for severe intensity

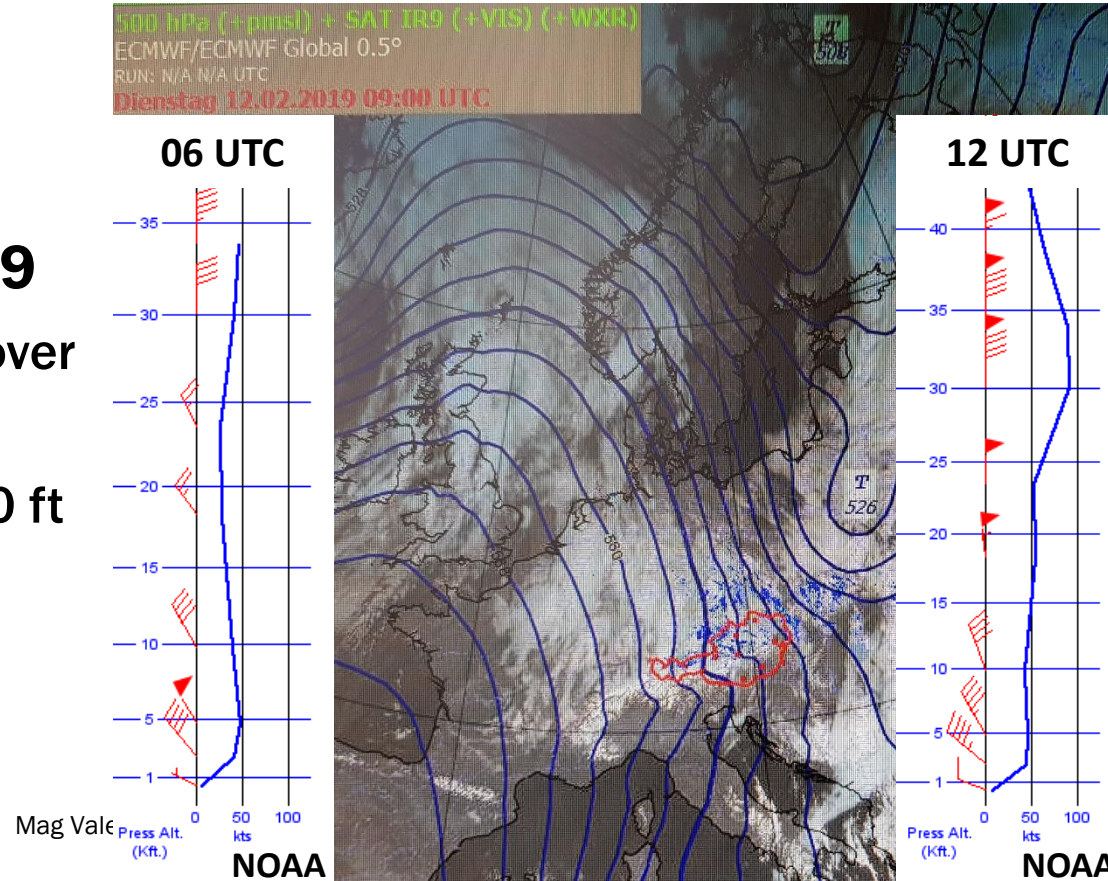


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A case study

- ▶ **SEV TURB 12.02.2019**
 - ▶ Polar jet core moving over AUT
 - ▶ Low-level-jet in ~ 5 000 ft over stable boundary layer in the morning
 - ▶ Lee wave formation



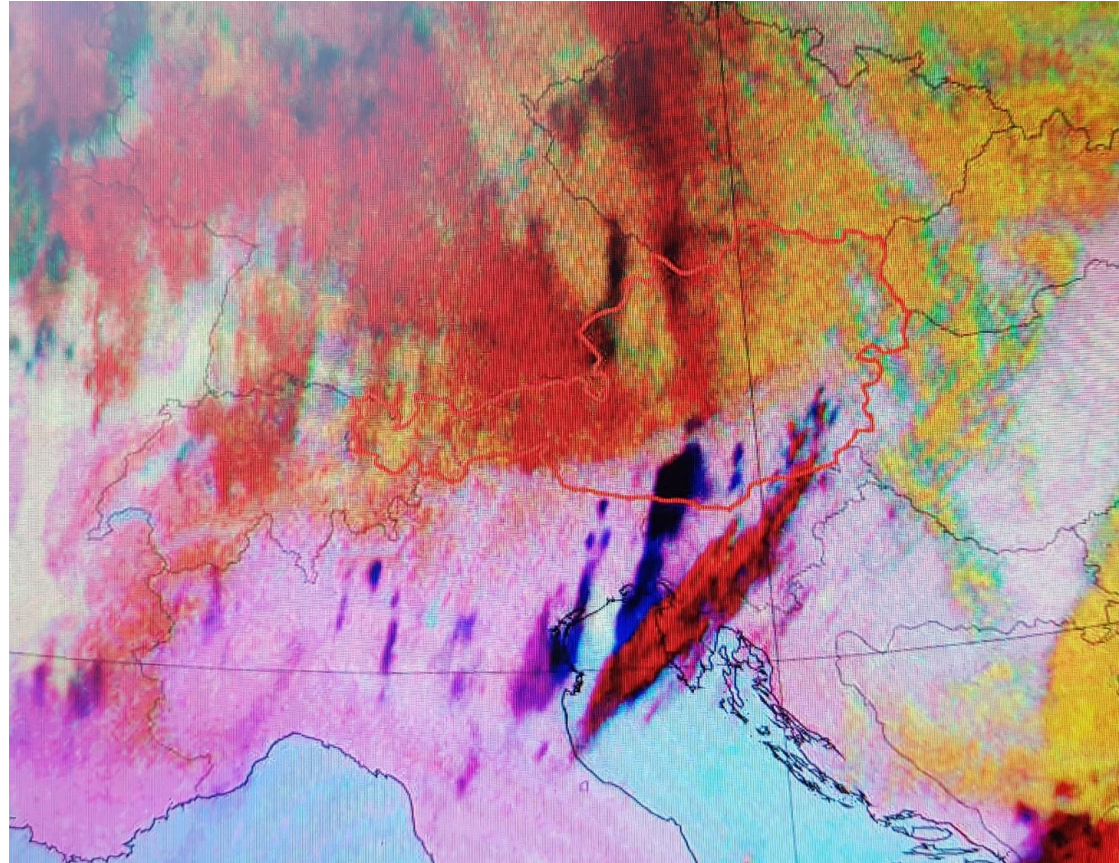


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A case study

- **stable cirrus clouds
with gap south of
the alpine main
ridge**

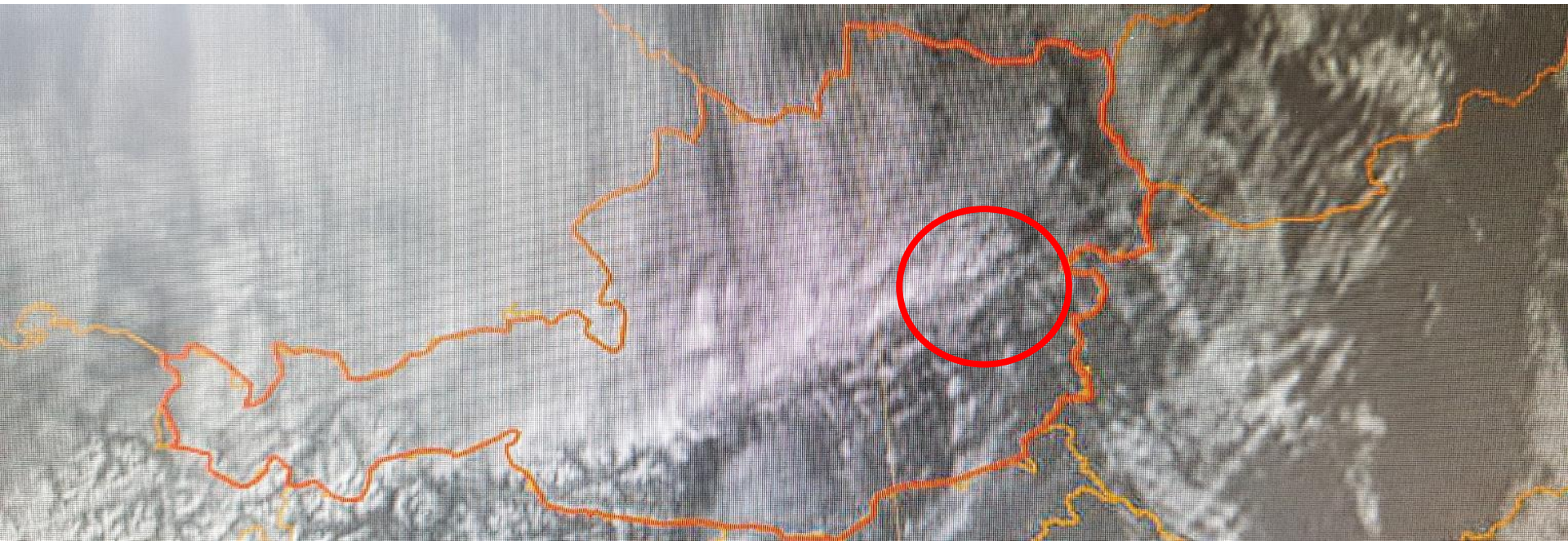




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**PIREP: UAOS61 LOWW 120808 ARS
INCOMING ACFT MEDIUM MOD/SEV TURB OBS AT 0806Z N4656 E01509
3000/9000FT=**

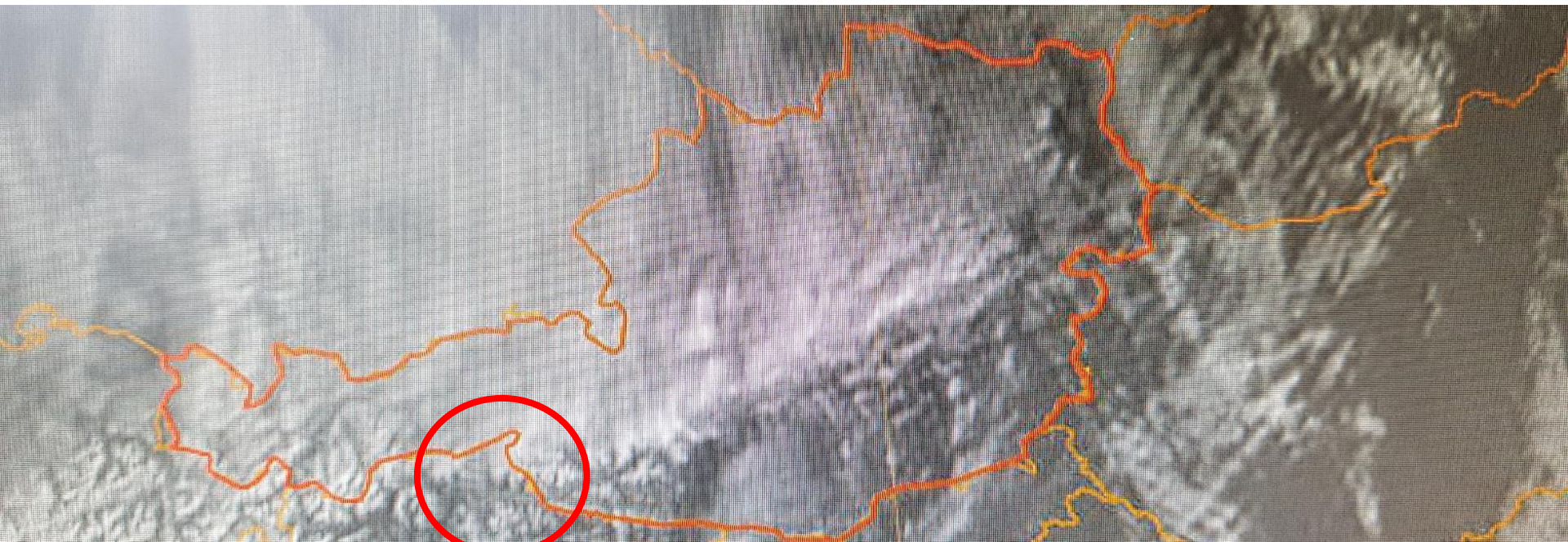




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**PIREP: UAOS61 LOWW 120828 ARS
ENRT ACFT MEDIUM MOD TURB OBS AT 0827Z N4727 E01156 FL380=**





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How can we improve nowcasting turbulence ?



BE AWARE!

DON'T JUST SHARE!



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