Turbulence

Types, Tips, and Mitigation

Harrison Sincavage / Joe Jurecka NWS WFO Lubbock, TX

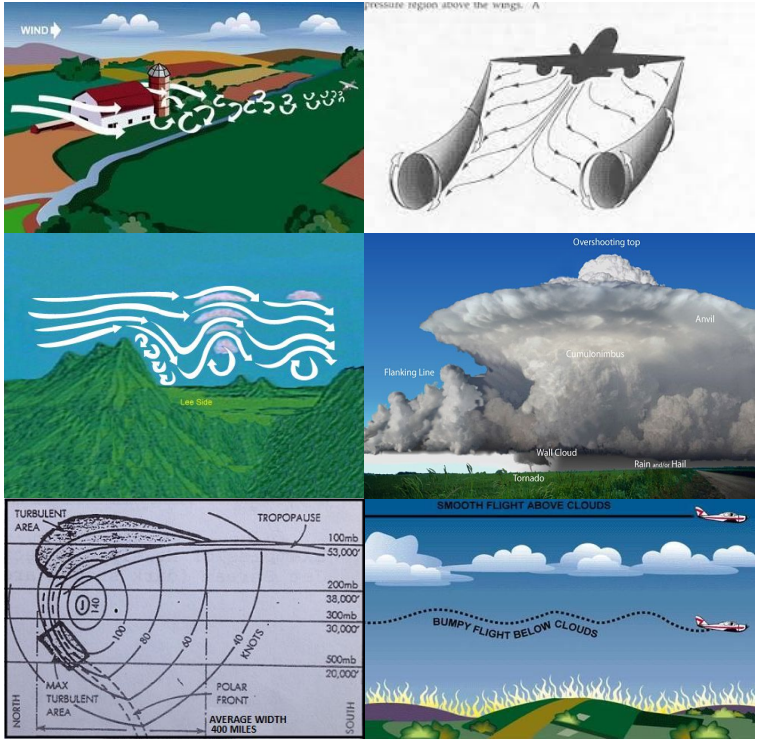
What is turbulence?

Turbulence is an irregular motion of air resulting from eddies or rising currents

It can cause erratic movements of the pitch, roll, and yaw

Types of turbulence

- Convective
- Mechanical
- Mountain Wave
- Clear Air
- Thermal
- Wake



How is it measured / reported?

- PIREPS
- ACARS (Eddy Dissipation Rate)

Eddy Dissipation Rate (EDR) is a measure of turbulence intensity without regard to aircraft characteristics.

The same EDR may produce perceived severe turbulence in a light aircraft but only light turbulence in an airliner.

Light is generally defined as <15,000lbs

Intensity	Symbol	Aircraft Reaction	Reaction Inside Aircraft
Light		Momentarily causes slight, erratic changes in altitude and/or attitude (pitch, roll, yaw).	Occupants may feel a slight strain against seat belts or shoulder straps. Unsecured objects may be displaced slightly. Food service may be conducted and little or no difficulty is encountered in walking.
Moderate		Changes in altitude and/or attitude occur but the aircraft remains in positive control at all times. It usually causes variations in indicated airspeed.	Occupants feel definite strains against seat belts or shoulder straps. Unsecured objects are dislodged. Food service and walking are difficult.
Severe		Causes large, abrupt changes in altitude and/or attitude. It usually causes large variations in indicated airspeed. Aircraft may be momentarily out of control.	Occupants are forced violently against seat belts or shoulder straps. Unsecured objects are tossed about. Food Service and walking are impossible.
Extreme		Aircraft is violently tossed about and is practically impossible to control. It may cause structural damage.	
Chop is a category of turbulence which causes rapid and somewhat rhythmic bumpiness without appreciable changes in altitude or attitude. May be reported as light chop or moderate chop.			

Turbulence Accidents & Incidents

Different causes but similar effects

Convective

- It doesn’t take a fully developed thunderstorm to provide a rough ride
- Thunderstorms can tear aircraft apart
- Just a few thousand feet depth of cumulus cloud can yield moderate turbulence
- Edge interfaces often rough
- Avoid convective build-ups especially those with cloud depth exceeding 10,000’

Convective Mitigation

- Avoid all thunderstorms
- Never go closer than 5 mi to any visible storm cloud with overhanging areas
- Do not attempt flight beneath thunderstorms even if visibility is good – Downdrafts/Virga
- At indications of turbulence, reduce to Va
- Plan to avoid all thunderstorms, from echo edge, by 20 mi
- Avoid areas of lofted dust
- AIRMETS / SIGMETS / CWAs

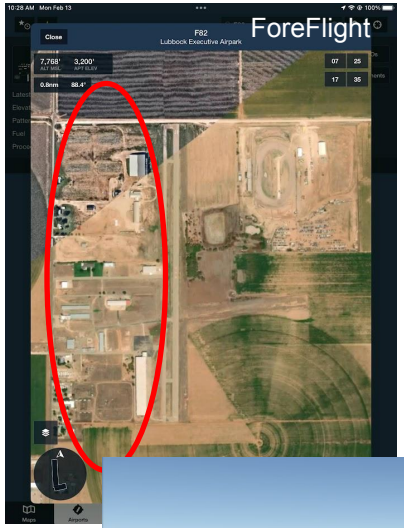
Remember, displays like this may be up to 20 minutes old!

Mechanical

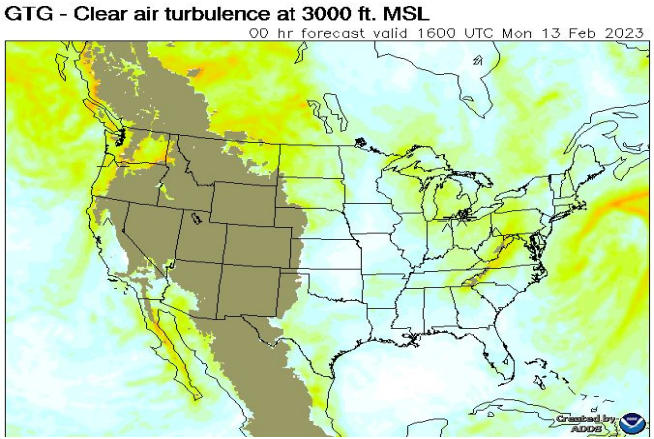
Flow over most objects induces turbulent flow for a least several hundred feet

Mechanical Mitigation

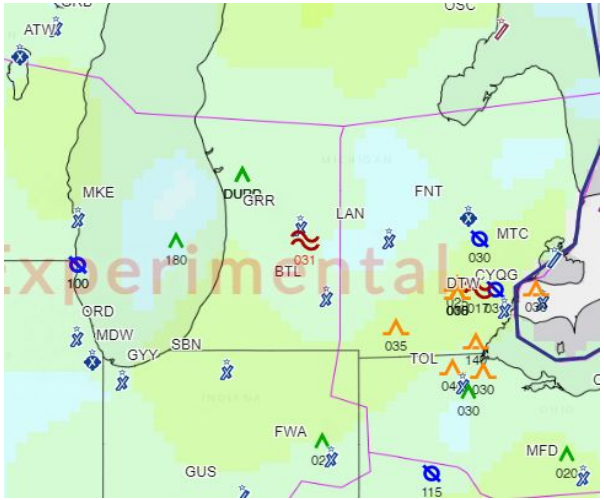
- Review aerial photography of critical directions (ForeFlight / Google Earth)
- Consider speed and direction at time arrival/departure
- Adjust flight times to minimize impacts
- Higher winds = higher impact

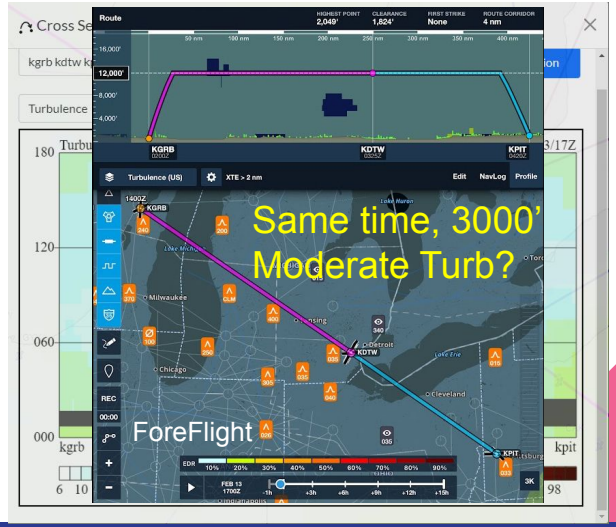


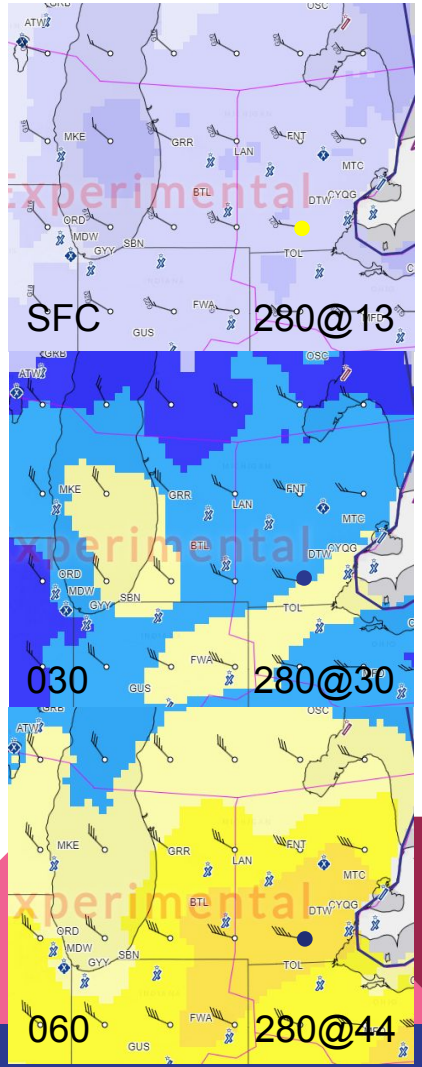
Clear Air (shear)



- Rapid Refresh Model (RAP) for Clear Air, Mountain Wave, Combo CAT/MTW (Updated hourly)
- No forecaster intervention so monitor AIRMETS/SIGMETS/CWAs
- Valid on the hour, not for a time range



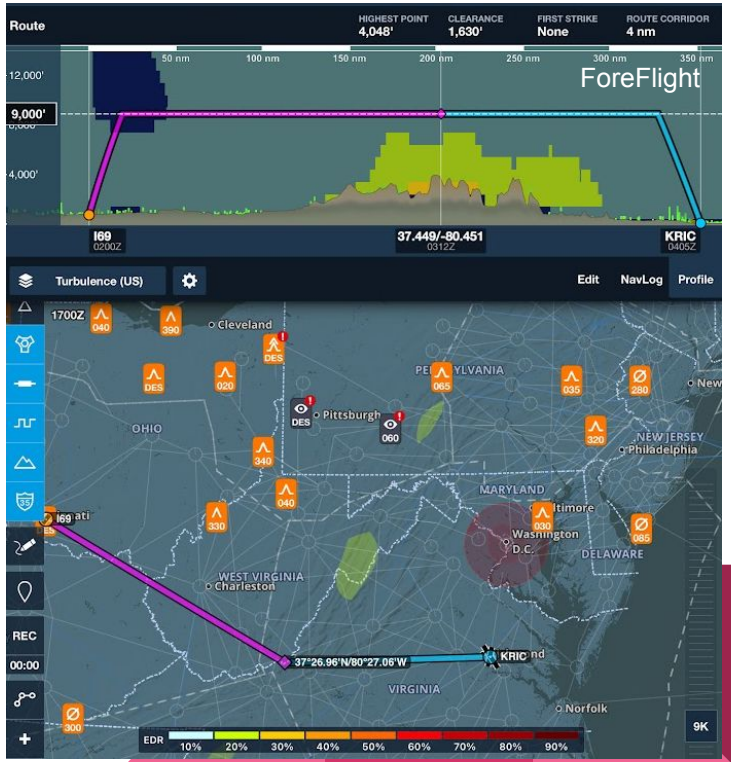




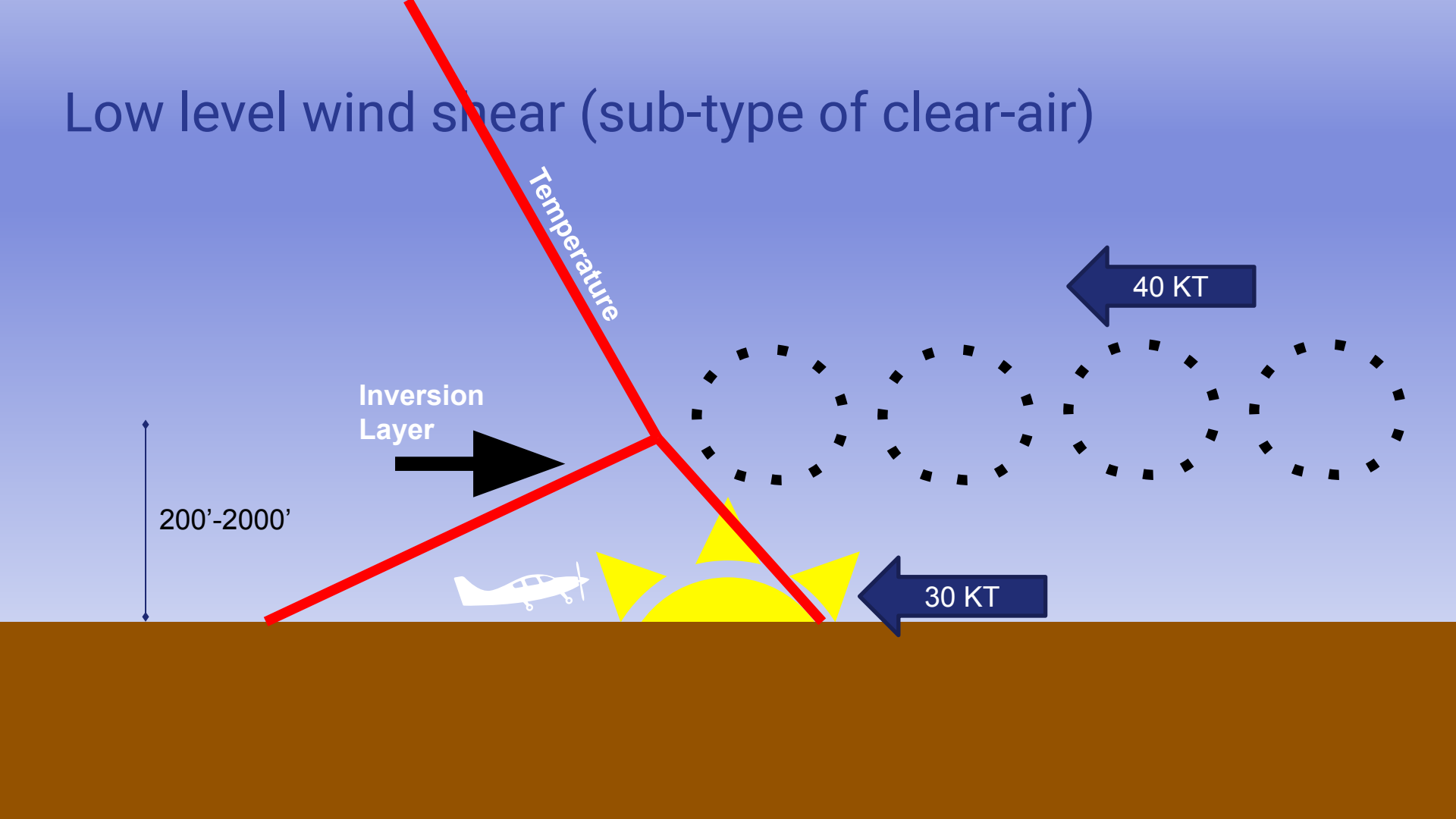
https://aviationweather.gov/turbulence/gtg https://beta.aviationweather.gov/gfa/#turb

Clear Air Mitigation

- Watch for vertical gradients ≥ 6 KT and/or 30 degrees per 1000’
- Consider all flyable altitudes / routes
- Consider scheduling changes to avoid
- Low and mid level turbulence often persist 12-24 hours behind strong fronts
- Use GTG and other turbulence products in concert. Different products use different techniques; use all available data
- Look for sharp vertical speed/direction gradients (>6KT/1000’ or 30º)
- AIRMETS / SIGMETS / CWAs



Low level wind shear (sub-type of clear-air)



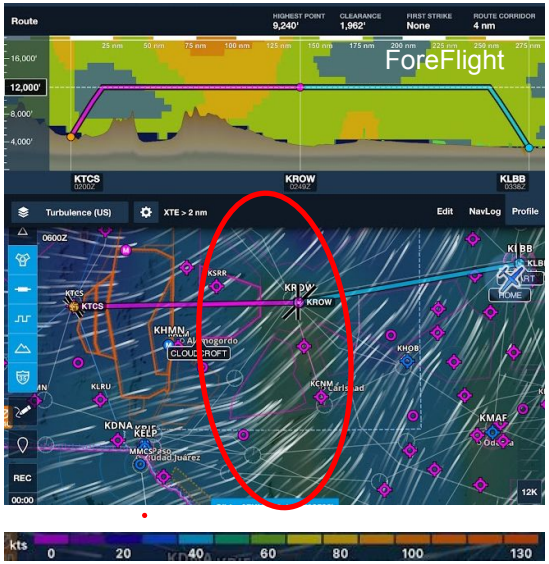
Low Level Wind Shear Mitigation

- Consider timing of LLWS
- Watch for near-calm wind at the surface, strong winds a few thousand feet aloft – Note direction and speed difference
- Not always bumpy – sometimes 50KT at 500’ and 10KT at surface is smooth as silk. Highly dependent on vertical temperature profile
- Anticipate wind effects in the pattern
- AIRMETS / SIGMETS / CWAs
- LLWS is to be in the TAF when shear exceeds 20 KT

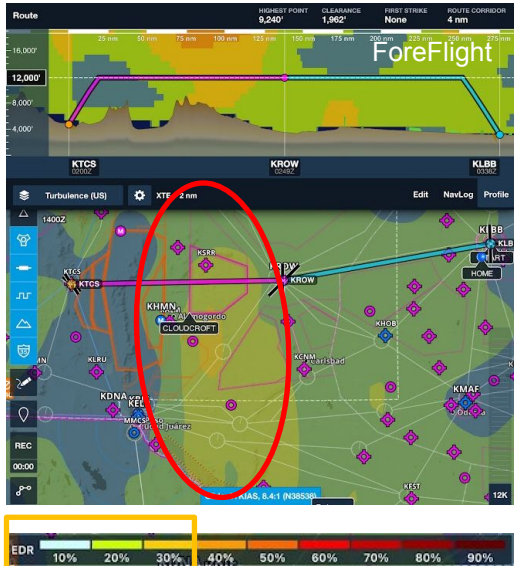
Mountain Wave

Intensity	Up/Down Draft Speed	Aircraft Speed Change	Aircraft Altitude Change
Moderate:	350-599 ft/min	+/- 15-24 KT	500-999 ft
Severe	≥ 600 ft/min	+/- 25 KT	≥ 1000 ft

- Criteria for forecast consistency
- No “official” ICAO criteria for consistency exists
- PIREP details are very important for mountain wave forecasts



• Mtn Peak Wind Speed Limit <- Light GA (25-30KT)

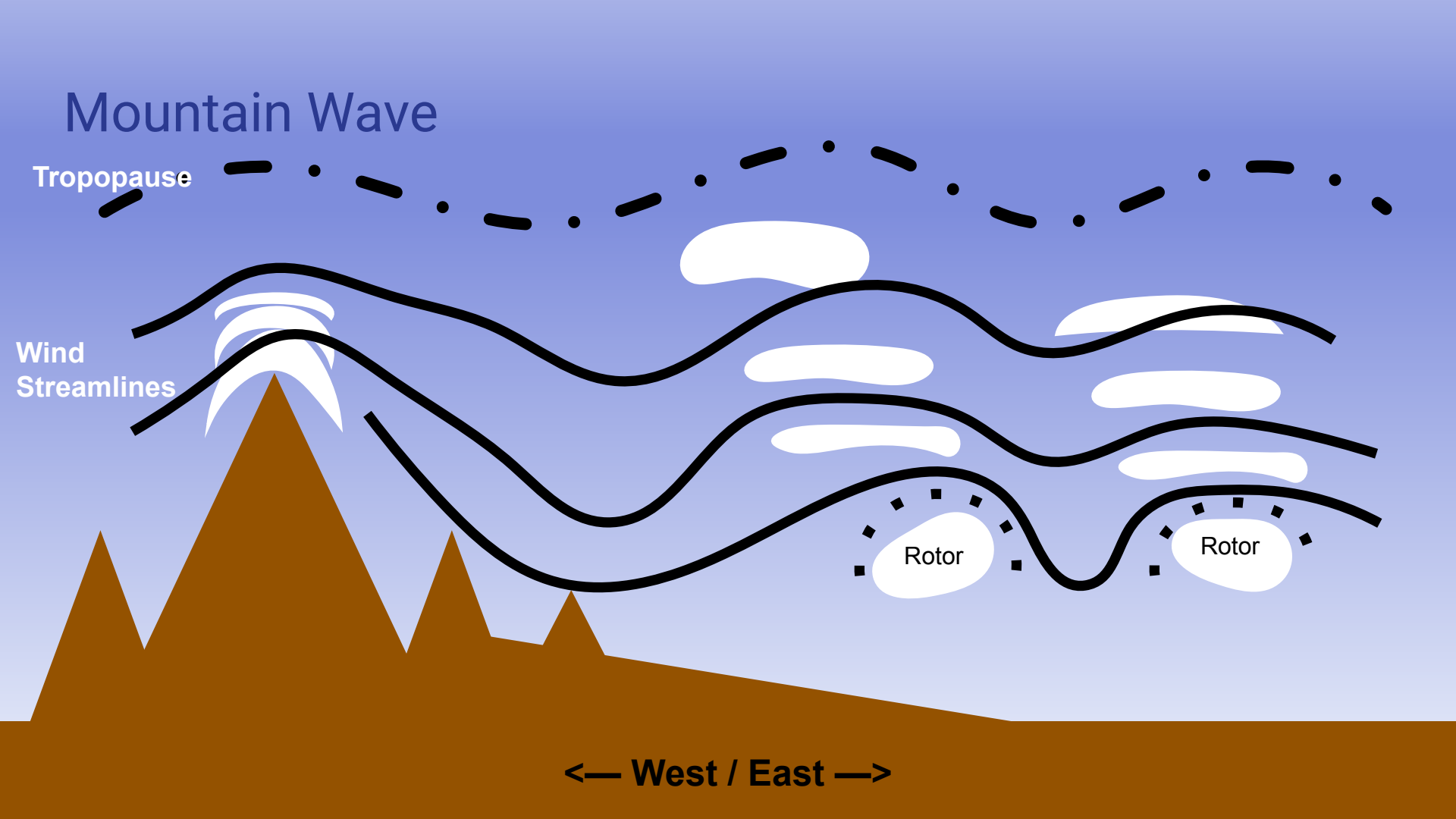


LGT MOD SVR <- Light GA

Center Weather Advisories (CWAs) issued by CWSUs do forecast MTW TURBC -- CWSUs across the western US, including ZDV and ZAB have agreed to use these criteria to describe MTW TURBC intensity

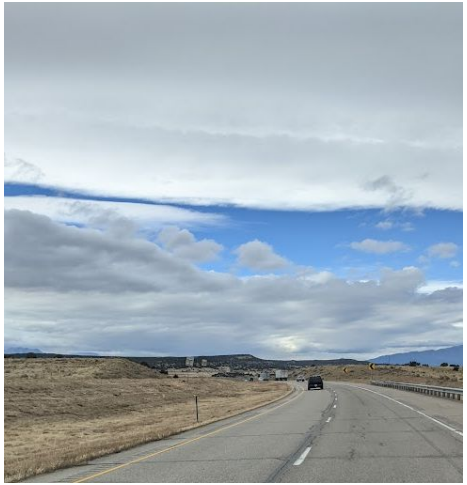
AWC does not forecast MTW TURBC until it is first observed, then a SIGMET is issued

Providing details in your PIREP MTW intensity, up/downdraft speed, aircraft speed change, and altitude change are critical. This is the only way forecasters know what is really being experienced

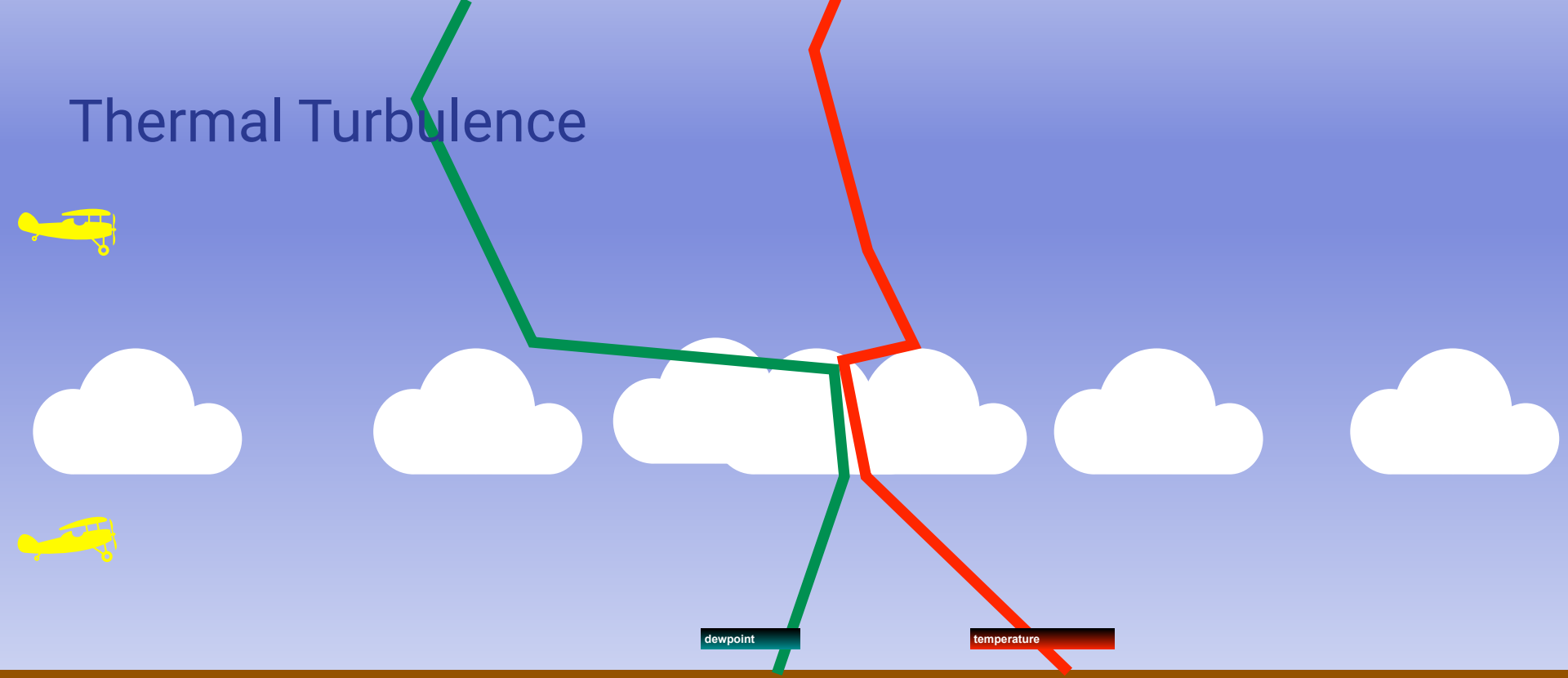

Mountain Wave
Tropopause
Wind
Streamlines
Rotor
Rotor
<— West / East —>

Mountain Wave Mitigation

- Avoid flying when mountain top wind speeds exceed 25-30 KT
- Use GTG (Mountain Wave or combined) to avoid area
- Find alternative routes (well north or south)
- Consider changing flight time or day



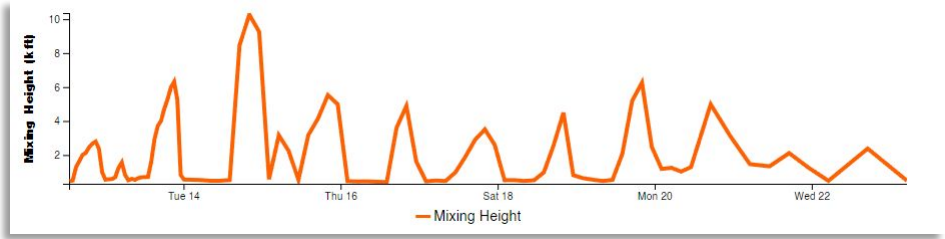
Thermal Turbulence



Thermal Turbulence Mitigation

- Typically light to occasionally moderate
- Not covered with GTG or most available turbulence products
- Consider flying before 10AM or within 1-2 hours of sunset
- Roughest rides 1-5 PM
- Turbulence exists surface to the **mixing height** during the day
- Try https://hwp-viz.gsd.esrl.noaa.gov/wave1d/?location=**KLBB**

Select **Fire Weather**, find Mixing Height near bottom (AGL)

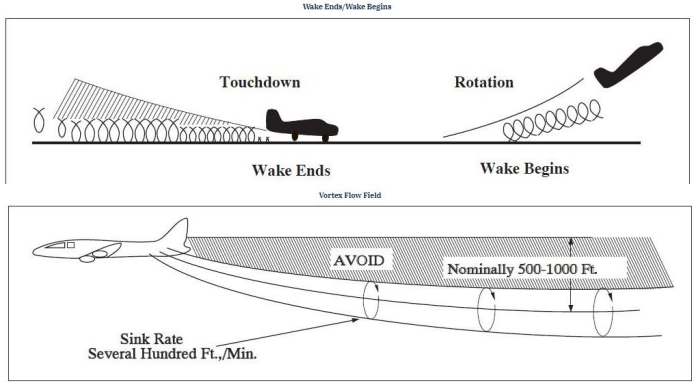


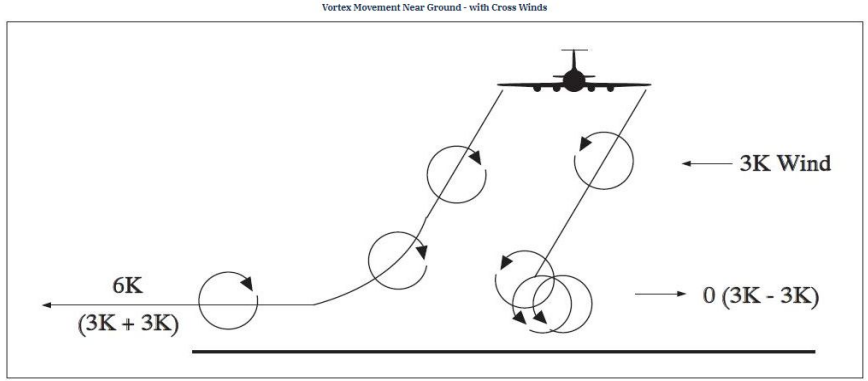
Wake Turbulence

- Use caution behind any aircraft larger than you!
- Can readily flip GA aircraft
- Sometimes, structural damage may occur

Wake Turbulence Mitigation

- Fly slightly above prior aircraft's vertical path (WT sinks several 100s fpm)
- Use ILS, LPV Path or Visual GPS path as a reference (~ 1 dot above)
- Touchdown beyond landing point of previous aircraft
- Liftoff prior to take-off point of previous aircraft
- Watch for aircraft passing crosswise ahead of you (especially slightly above!)
- Consider wind propagation and don't forget helicopters!





See AIM Chapter 7, Section 4

Suggestions for putting passengers at ease

- Communicate the turbulence risk before the flight – set expectations
- Focus on *most-likely* experiences – **not worst case**
- Advise passenger what you'll do in the event of turbulence
- Offer a bubbling brook as an analog for air flows
- Consider distractions, cooling on back of neck, breathing tips, medication **[not flight crew]** (meclizine)
- Reassure that airframes are designed to handle turbulence and the pilot is trained to handle it
- Talk about airsickness, early symptoms (sweating, belching, etc.) and mitigation (head back, look outside, airflow)…locations of sick sacks

Many travelers are more concerned with nausea than the turbulence itself

Concluding Remarks / Questions

See: FAA-H 8083-28 Aviation Weather Handbook – Lots to learn and it's free!

THANK YOU!