Western Region Technical Attachment
No. 92-18
May 5, 1992

A GOOD EXAMPLE OF A "FOEHN GAP" ON SATELLITE IMAGERY

A "Foehn gap" is just one name given to the cloud-free zone often seen in the cirrus just to the lee of major mountain ranges when wind and moisture conditions are just right. This zone has also been referred to as a "cloud-free trench" and a "lee-side clear trench". This cloud-free zone may have been noted first by S. J. Reid in 1975, who used the term "Foehn gap" to describe this phenomenon near the Alps of New Zealand since it was associated with warm downslope winds resembling the European Foehn winds (Reid, 1975). Since then, this same feature has been studied over our own Rocky Mountains by many, including Gary Ellrod of NESDIS. This Technical Attachment references Ellrod's 1987 paper which was presented at the AIAA 25th Aerospace Sciences Meeting in Reno.

According to Ellrod, these phenomena identified in satellite imagery are almost always associated with high altitude mountain wave turbulence. These events require strong westerly or northwesterly flow, and usually occur just as the ridge is approaching the front range and often amplifying as a short wave approaches from the west. Figure 1 shows that at 500 mb on the morning of April 28, 1992, this was again the case, with the ridge axis near the Idaho/Montana border and a weak short wave moving across Washington and Oregon. The atmosphere must also have enough moisture in the upper levels for cirrus to be present, as it was on the 28th as well.

The visible satellite image in Fig. 2 shows that by 1730Z, a cloud-free zone or "Foehn gap" had developed, hugging the lee side of the Rocky Mountain front range in Montana. By 1830Z (Fig. 3a) the gap was still coherent and in the same location; the feature persisted for about two hours on this particular day. In all the cases that Ellrod has studied, the gaps remained distinct for at least two hours.

Figure 3b is a zoomed view of the 1830Z visible image; note the sharpness of the gap all the way up into Alberta. Hopefully (despite the poor reproduction), you can also make out the familiar "washboard" pattern west of the cloud-free zone, long associated with low-level turbulence in the stable air just above the mountain tops. The infrared image in Fig. 4 (valid at 1800Z) shows that the downstream cirrus is brighter (thicker and colder) than the clouds upstream from the gap, having been enhanced by strong upward motion from the intense wave action. This is another common observation in the cases that Ellrod has studied.

In most of these cases, the most severe turbulence was found on the extreme west edge of the coldest cirrus (or just where the clouds appeared again downstream from the cloud-free zone). We could not find any reports of severe turbulence in Montana on this day, which may only reflect the fact that few aircraft fly routes over northern Montana. These events are also often associated with strong downslope winds at the surface ("Chinook" winds in this part of the world). However, the surface winds on this day were not very impressive by Montana standards; gusts along the east slopes of the Rockies were generally in the 20-30 knot range.

Despite the lack of verifying high-level turbulence and strong surface winds, the signature of the Foehn gap on satellite imagery can be an extremely valuable tool in the short-term forecasting of turbulence, especially in areas where pilot reports are often scarce. The dissipation of this signature, Ellrod suggests, should signal the end of the worst turbulence. The fact that the Foehn gap feature was rather short-lived on this day may have allowed severe turbulence to come and go before any high-altitude aircraft had the opportunity to experience it.

References

Ellrod, G.P., 1987: "Identifying High Altitude Mountain Wave Turbulence and Strong Chinook Wind Events with Satellite Imagery". AIAA 25th Aerospace Sciences Meeting, January 12-15, Reno, NV.

Reid, S.J., 1975: "Long Wave Orographic Cirrus Seen From Satellites". *Weather*, 30, p117-123.

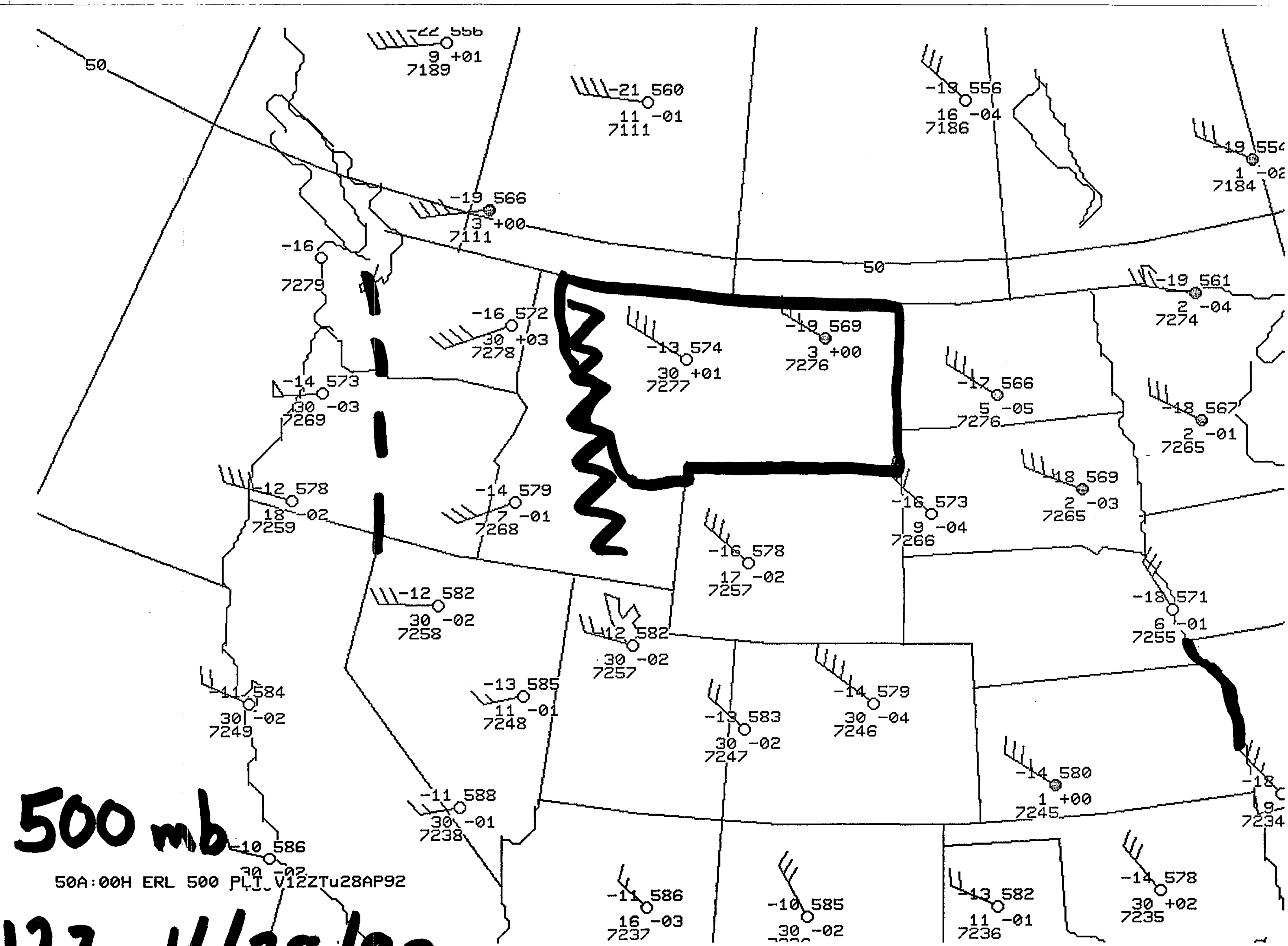
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Fig. 1

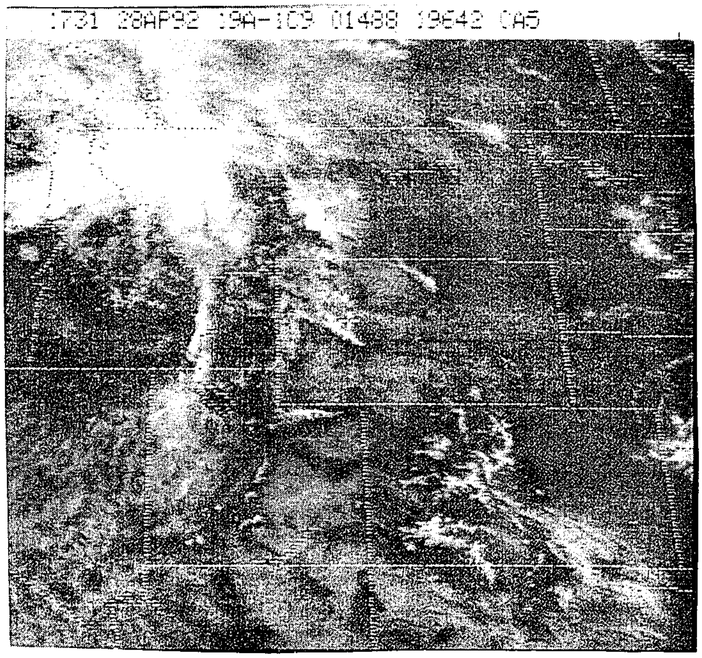

Fig. 2

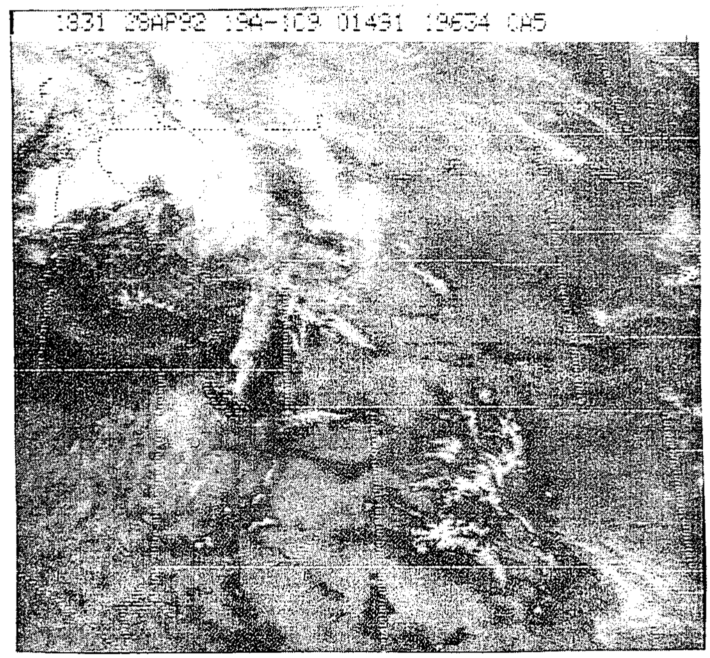

Fig. 3a

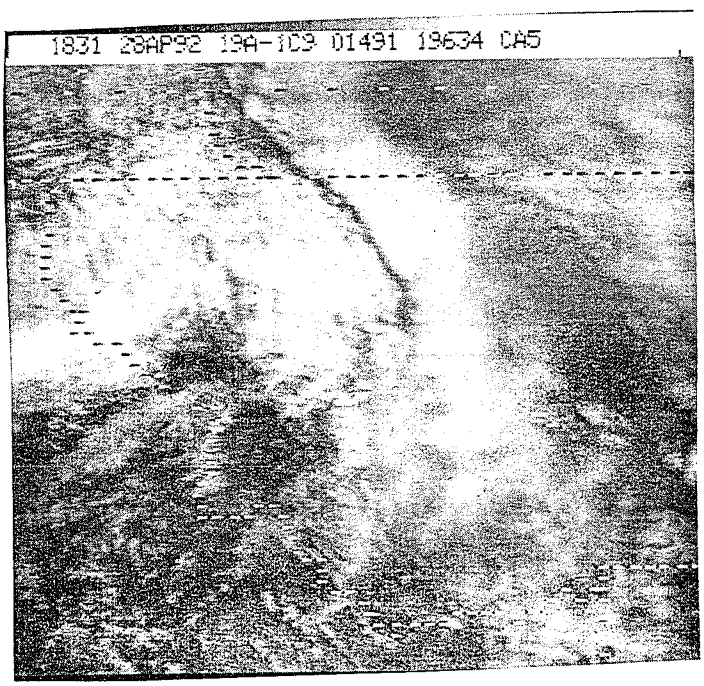

Fig. 3b

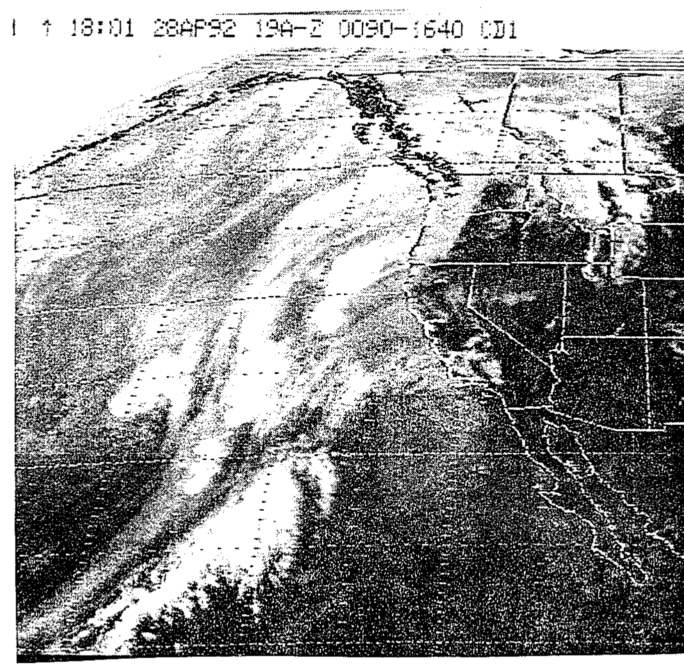

Fig. 4