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TURBULENCE AREAS INFERRED FROM SATELLITE CLOUD PATTERNS

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INTRODUCTION

In the near future, the cloud analysis program will be extended to include cloud top heights, turbulence and possibly icing areas on the depiction charts. This note will serve as a reference for the satellite meteorologists at PWC as well as an information paper for the intended users.

TURBULENCE AREAS IDENTIFIABLE ON SATELLITE IMAGERY

Turbulence can often be associated with specific structural features within the cloud field. The presence and locations of these features may be determined by careful analysis of satellite imagery.

The purpose of this paper is to outline certain cloud structure - turbulence relationships considered by the satellite meteorologist at PWC. As well, turbulence representation on the PWC significant weather analysis and prognosis is outlined.

CLOUD FEATURES IDENTIFIED WITH TURBULENCE

1. Frontal Cloud Bands

The entire frontal cloud band is considered as a high probability turbulence area. Turbulence associated with regions of embedded convection developing waves, or a rapidly moving back edge is assumed to be more severe. Turbulence associated with frontal cloud is generally found below 20,000 feet. (Higher level turbulence may be jet related.)

2. Jet Stream

Weldon has outlined rules for determining jet stream and wind maximum location, the procedures for which have become routine at PWC.

Turbulence has been found to occur on both sides of sharp jet related cirrus cloud edges. The turbulent area is generally confined to within 3 degrees latitude of the jet axis. A higher degree of turbulence is associated with dense overcast cirrus. Scattered cirrus is connected with light or non turbulent conditions.

Subtropical jets differ somewhat in that the more turbulent area is found within the lower two thirds of the associated cirrus deck.

A higher risk of severe or extreme turbulence exists when transverse bands or cloud trails are observed near the jet. Jet related turbulence is primarily high level.

3. Mountain Wave Clouds

Turbulence occurs more frequently over mountains than over flat terrain. Air flow experiences deformation on the leeward sides of mountain ranges. If moisture, stability and flow direction are favourable, mountain wave clouds become evident. Most of the associated turbulence is experienced close to the mountain range with a lesser degree downstream. Mountain wave turbulence is generally confined to levels below 20 thousand feet and often marked by mid and low clouds. (Higher level turbulence can likely be attributed to a jet stream above the wave cloud.)

4. Sharp Boundaries Between Solid Cloud Cover and Clear Skies

Associated turbulence near the boundary is apparently caused by an abrupt change in the sign of large scale vertical motions between cloud and cloud free areas. The difference in motions may be of significant enough scale to affect aircraft.

5. Convective Clouds

Convective clouds evident on satellite imagery identify turbulent areas. The turbulence area is not confined only to the cloud but also to the adjacent clear area.

Cumulus and towering cumulus are generally associated with light to moderate turbulence. As open cells develop vertically and take on a larger and brighter appearance, the intensity probability increases.

Cumulonimbus appearing either as cells or clusters indicate the presence of moderate to severe turbulence. This turbulence can extend to at least 5,000 feet above cloud top level.

6. Positive Vorticity Advection Maxima (Abbreviated PVA Max.)

PVA Max. are seen on satellite imagery as areas of enhanced cumulus or comma shaped cloud patterns within the cold air behind a front. They are associated with mid-tropospheric shortwaves. Favoured areas for turbulence lie within the northeast quadrant of the PVA Max.

Turbulence is most likely when thermal gradients associated with fronts, frontal waves and positive vorticity maxima, become stronger with time. Sharpening cloud edges and tightening of satellite derived thickness fields associated with these features should also be considered.

TURBULENCE REPRESENTATION AT PWC

An attempt is being made to outline turbulent areas both spatially and as to degree of intensity.

1. Probable turbulent areas are outlined by a heavy dashed line. The areas are then branded by the "hat" character ^ .
2. Regions of stronger horizontal or vertical shears within the general turbulence areas are highlighted with an array of "+++" to indicate the

likelihood of more severe turbulence.

3. Vertical extent of a turbulent layer is denoted by means of a single letter qualifier to the right of the ^ symbol.

An "M" denotes turbulence within the mid levels of the troposphere (850mb-500mb). An "H" implies turbulence in the high levels (above 500mb).

A ^ symbol with no qualifier assumes turbulence applies to the entire column of air.

Forecasting of low level turbulence is a continuous issue. As well low level cloud indicators are often obscured by overlying cloud. Thus analysis and forecasts of low level turbulence are left to the aviation forecaster.

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FIGURE 1.

EXAMPLES OF PWC TURBULENCE DEPICTION

