



NCAR

# Progress in Turbulence Information – Product Research and Development

Presentation at the NBAA/FPAW Forum

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# In situ Turbulence Measurement and Reporting System



## Goal:

- Augment/replace subjective PIREPs with objective and precise turbulence measurements.

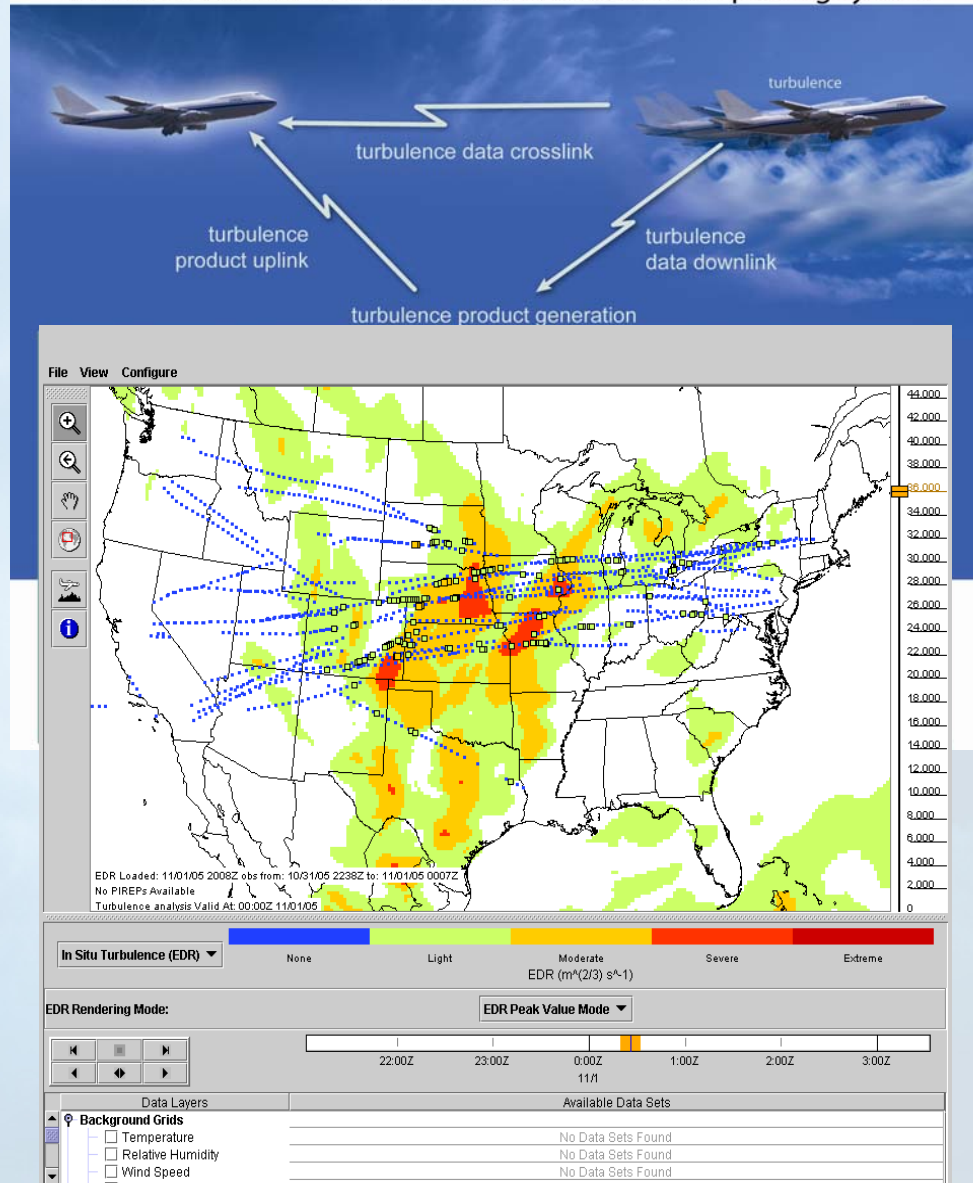
## Features:

- Atmospheric turbulence metric: eddy dissipation rate (EDR).
- EDR can be scaled into aircraft turbulence response metric (RMS-g).
- Adopted as ICAO Standard

## Status:

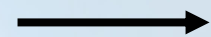
- ~ 200 UAL aircraft now
- Begin SWA fleet-wide implementation by June 2007, completed by end of 2007 (~400)
- Delta, NWA ?

FAA/NCAR In situ turbulence measurement and reporting system



# NEXRAD in-cloud turbulence detection algorithm (NTDA)

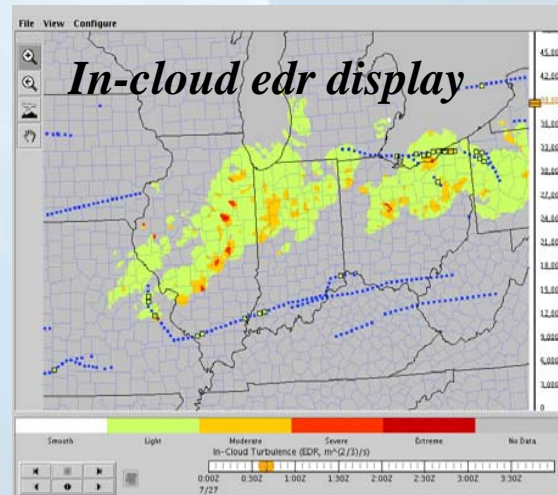
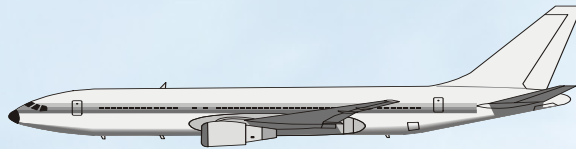
- Ground-based displays
- Cockpit displays from uplinks
- Scheduled for ORPG Build 10 NEXRAD update (operational 2009)
- POD~80%, FAR~25%



```

EXP TURB FI UAL
-- 20 Oct 2005 22:08:57Z
FL 360 orient. 95 deg
'X'=aircraft, '+'=waypoint, '*'=route
' '=no_data, 'o'=smooth, 'l'=light
'M'=mod, 'S'=severe
----- (36nm to COWES) -----
1111 1*MMMMM11
112nm 111 11*11MM1111
      11M*MMMMMM11
108nm 11M*MM11MMMM
      11M*MM111MM
104nm 1MM*1111
      M1*1
100nm 1**1
      11 o1 1*11
096nm 1111111111*111
      11111111111*11
092nm 11111111111*11
      1111111111 1*11 111111111
088nm 11111M11MM111*1 111111111
      111MMMMM11 * 11111111111
084nm 1111MMMMMM ** 1111111111111
      11111MMMMM1 *111111111111111
080nm 11111MMMM *111111111111111
      1111M1MMM 1*111111111111111
076nm o11MM111 1 1*111111111111111
      o11MM1111111M*1111 1111111
+STL 1111111111M1+111 1111111
      11 111 M11*111 111111
068nm 11 111111M11*111M 111111
      111 111111111*11MM 111111
064nm 111 11111111*11MM 111111
      1 11 11111111*11MM 111M11
060nm 111 111111111M*MMM 111MM11
      11 11111111M1M*M MM11MMMM
056nm M1 111111M1M*M M1MMMMMM
      M 1 111111M1M*M1 M1MMMMMM
052nm 1 1111111111M*M1111MMMMMMMMMM
      111 1111111111M*M1111MMMMMMMMMM
048nm 111 111 o111111M*M11MM SSM MMMMM
      11M 111oo11111111*1111M SSM SSM
044nm 11MM111o11111111*1111M SSM MMMMM
      11MM 1111 11111*1111MMMMMM11MM
040nm M 11111111111*11111MMMM111MM
      111MM1111111*11111MM1111111
036nm MM11MM11 11*111111111111111
      MMM11M11 111*11111111111
032nm MMM111111 oo1*1 111 1111
      MMM1111111o1*1 1
028nm MMM111111MM1*
      1MM111 MM1*
024nm M M *
      M *
020nm MM11 *
      M11111 ** MMM
+WELTS 1111 + 11MM
      111 * 11MM
012nm 11 * 11MM
      *
008nm *
      *
004nm *
      *
valid -----X-----
2205Z -40nm (39.0N, 92.1W) +40nm
    
```

EDR



NEXRAD or TDWR

Severe

# Turbulence forecasts – GTG2

- Extends GTG1 to 10,000 ft MSL
- Improved accuracy at upper levels
- Uses UAL in situ data
- Status
  - D4 scheduled for 16 Nov 2006
  - Operational on ADDS early 2007

Experimental  
@aviation digital data Service

NCEP | NWS | AWC

disclaimer | forum | feedback | FAQ | about ADDS

@dds Home | METARs | TAFs | PIREPs | AIR/SIGMETs | Satellite | Radar  
Turbulence | Icing | Convection | Winds/Temps | Prog Charts | Java Tools

FYI/Help

- Graphical Turbulence Guidance (GTG)  
[ [GTG Performance Statistics](#) ]

Jul 22	1900 UTC	<a href="#">(2006072219_F00_GTG.grb)</a>	FL420
	2000 UTC	<a href="#">(2006072217_F03_GTG.grb)</a>	FL390
			FL360
			FL330
			FL300
			FL270
			FL240
			FL210
			FL180
			150
			120
			Composite

The GTG is an automatically-generated turbulence forecast product that supplements AIRMETS and SIGMETs by identifying areas of turbulence. The GTG is not a substitute for turbulence information contained in AIRMETS and SIGMETs. It is authorized for operational use by meteorologists and dispatchers.

### Turbulence forecast at 12000 ft. MSL

12 hr forecast valid 0300 UTC Sat 14 Oct 2006

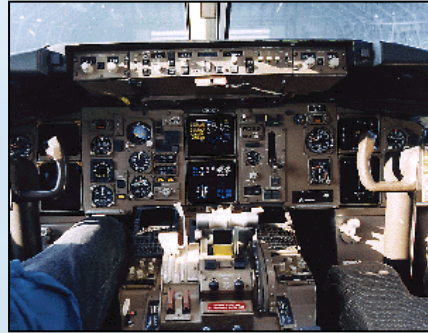
None | LGT | MDT | SVR | Extreme



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# GTG-N

- Tactical avoidance tool
- Merges all current turbulence observations
- Updates every ~ 15 min
- D3 expected 11/08

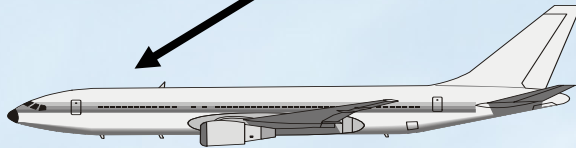


*Cockpit display or alert*



*ADDIS: Dispatch, ATC, etc.*

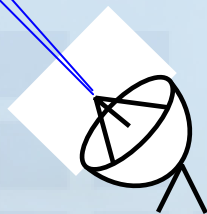
Graphic courtesy of  
virtualskies.arc.nasa.gov



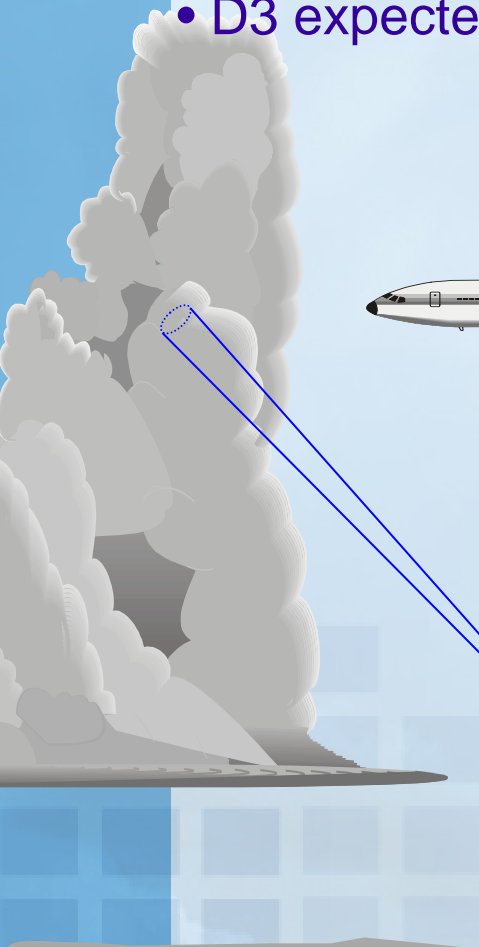
*In-situ reports,  
PIREPs,  
MDCRS winds  
and temperatures*



*GTG grids  
CIT diagnostics  
Satellite data  
Conv. Wx nowcasts*



*NTDA grids*

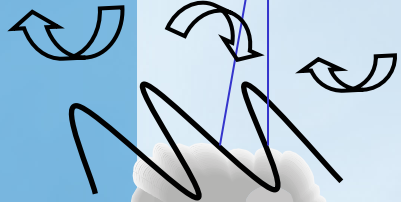
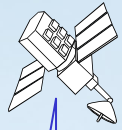




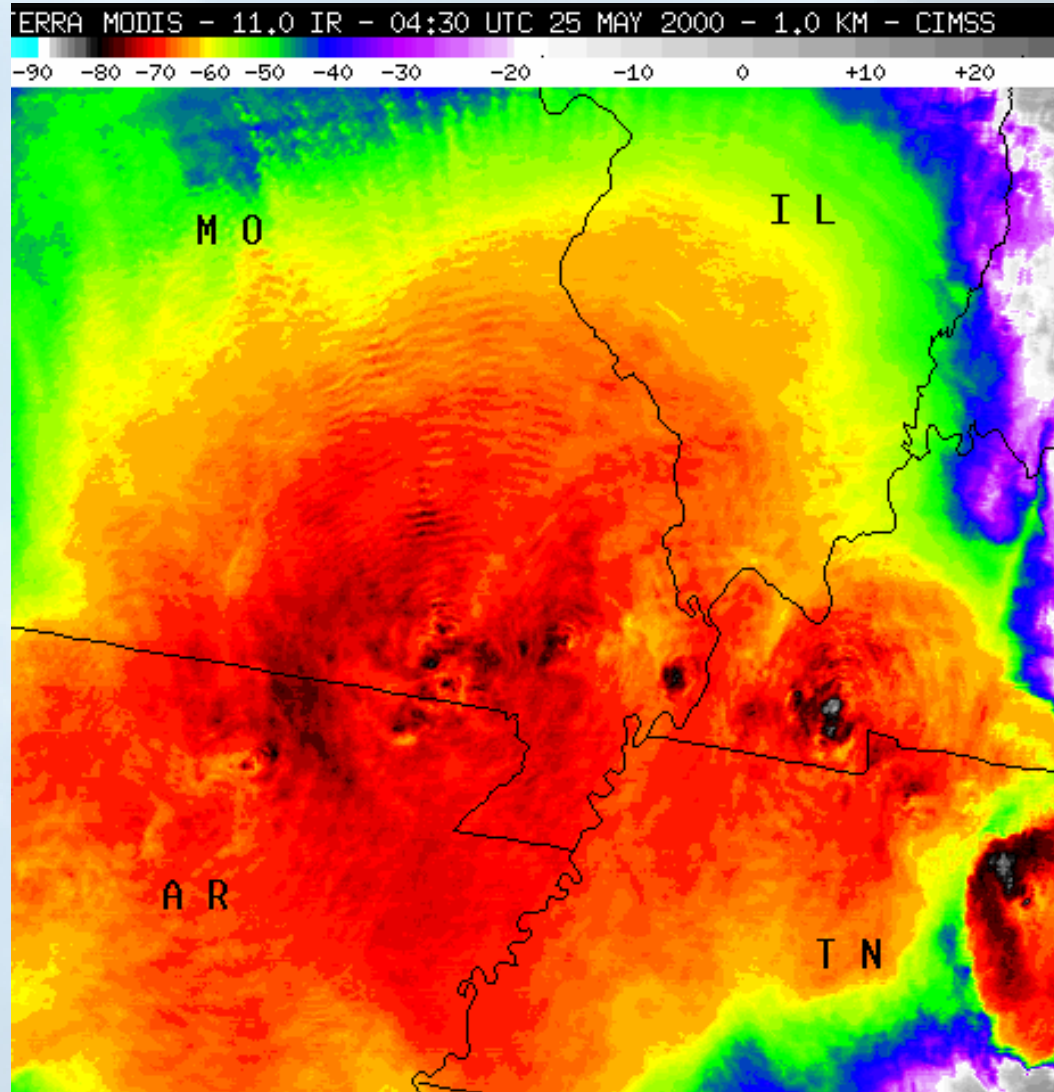
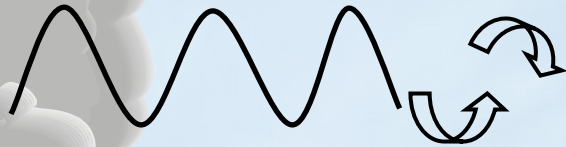
# NASA CAN: Relate CIT to gravity waves -> GTG-N



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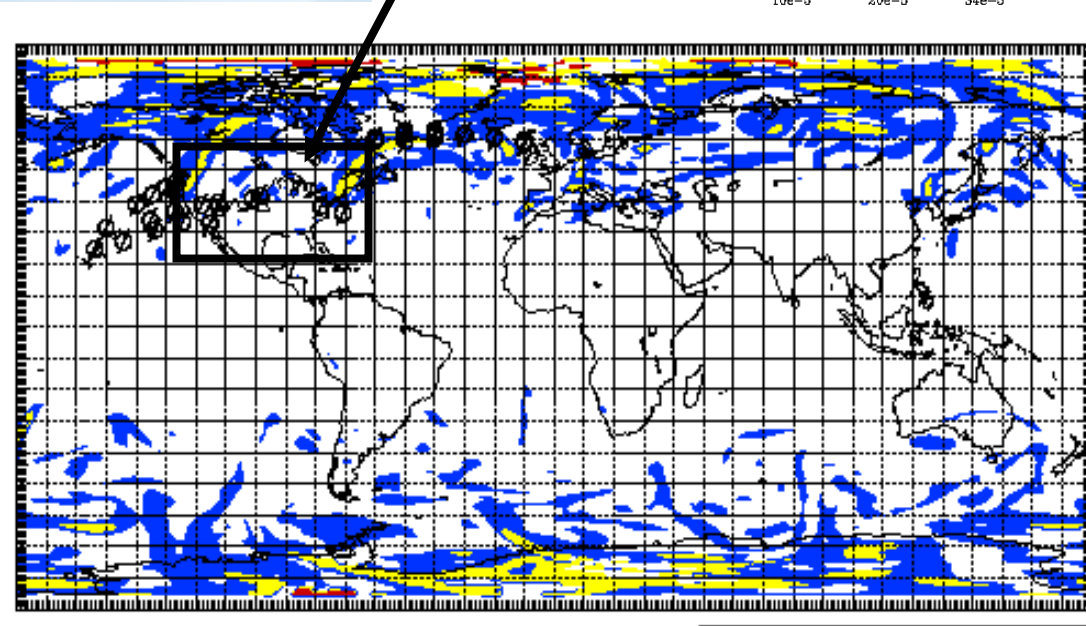
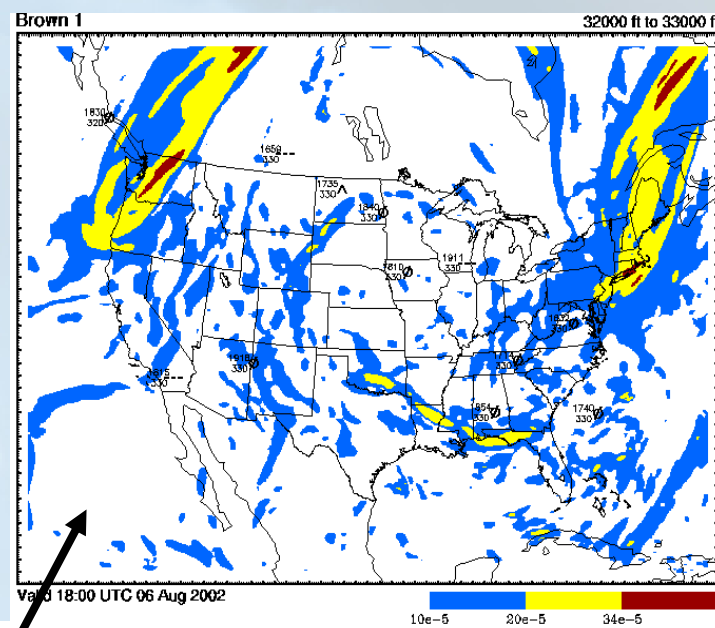


Convectively-induced gravity waves and turbulence



# Global GTG

- Uses NOAA's GFS model
- Diagnoses and forecasts of CAT > FL200
- Status
  - D3 was expected in 11/07
  - Operational early 2010
  - Delayed or cancelled



Example: Brown's index at FL320 06 Aug 2002 18Z Upper: RUC20 Lower: GFS





# Projected GTG releases – next 7 years

Version	Capabilities	D3	D4	Op
GTG1	Upper levels RUC20	---	3/03	3/03
GTG2	Improved GTG1 Mid levels RUC13 Text generation Uses in situ	11/04	11/06	2/07
GTG3	Improved GTG2 MWT 10 km RR WRF Probabilistic forecasts	11/07	11/08	2/09
GTG/TFO	Global - GFS	11/07	11/09	2/10
GTG4	Improved GTG3 out-of-cloud turb forecasts	11/08	11/09	2/10
GTGN	Rapid upates in-cloud turb nowcasts in situ GTG4 0-2 hr analyses	11/08	11/09	2/10
GTG5	Improved GTG4 Low levels	11/09	11/10	2/11

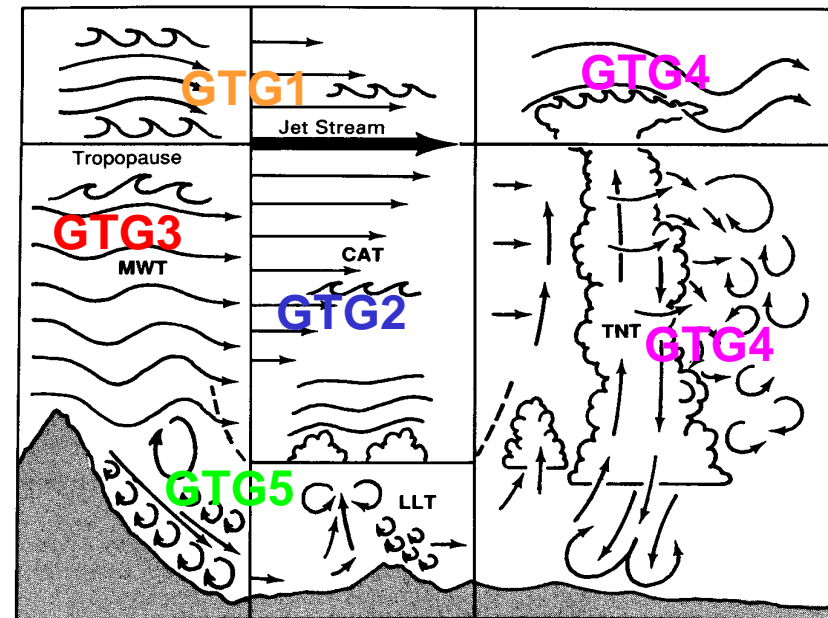


Figure 1-16. Aviation turbulence classifications. This figure is a pictorial summary of the turbulence-producing phenomena that may occur in each turbulence classification.

Source: P. Lester, "Turbulence – A new perspective for pilots," Jeppesen, 1994