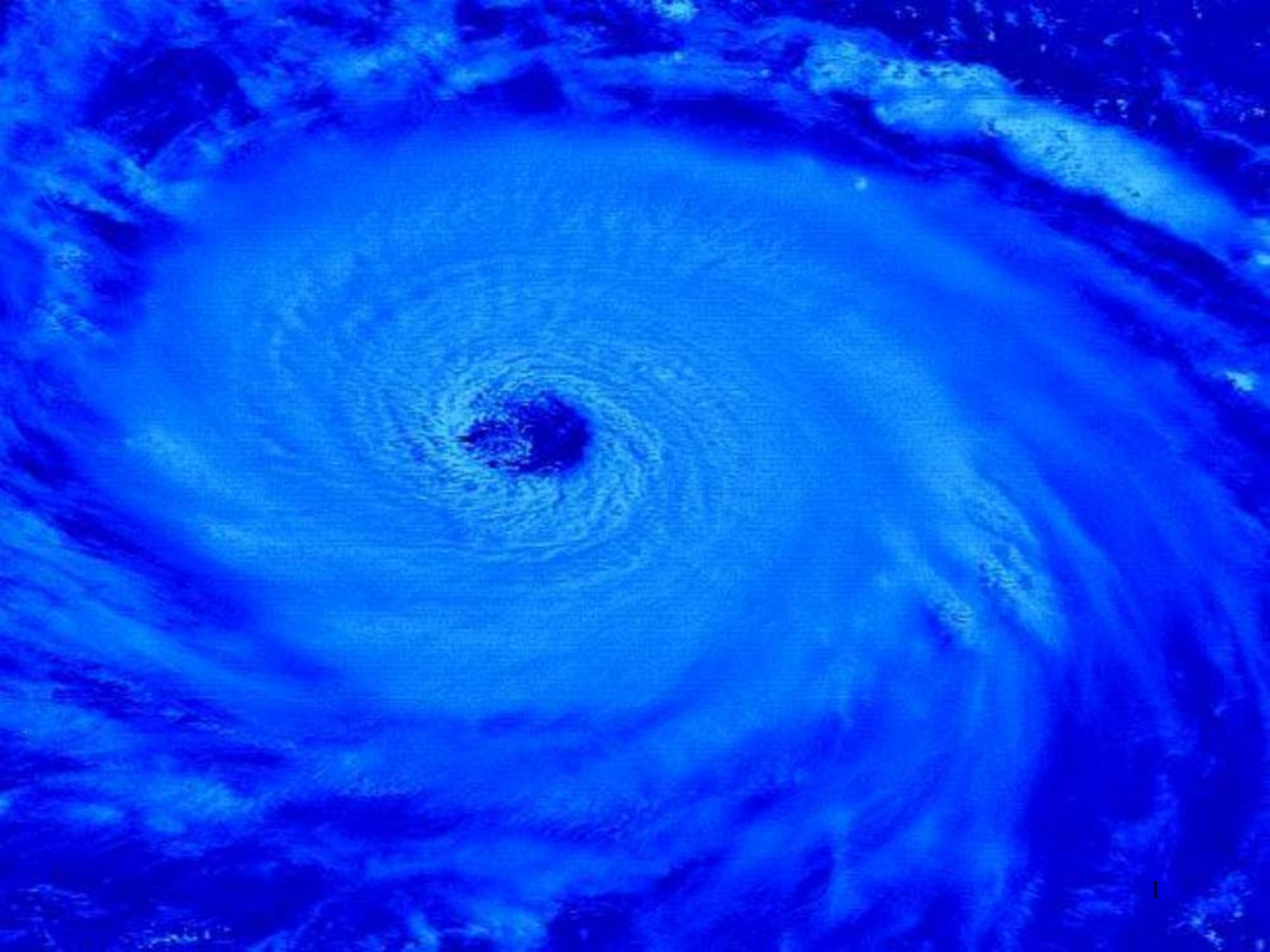
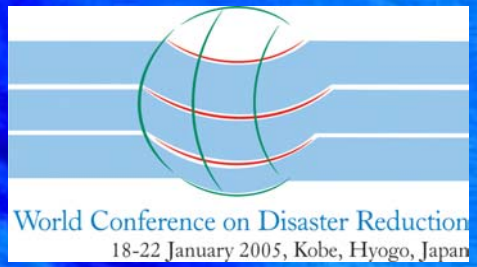


# EARLY WARNINGS FOR HURRICANES





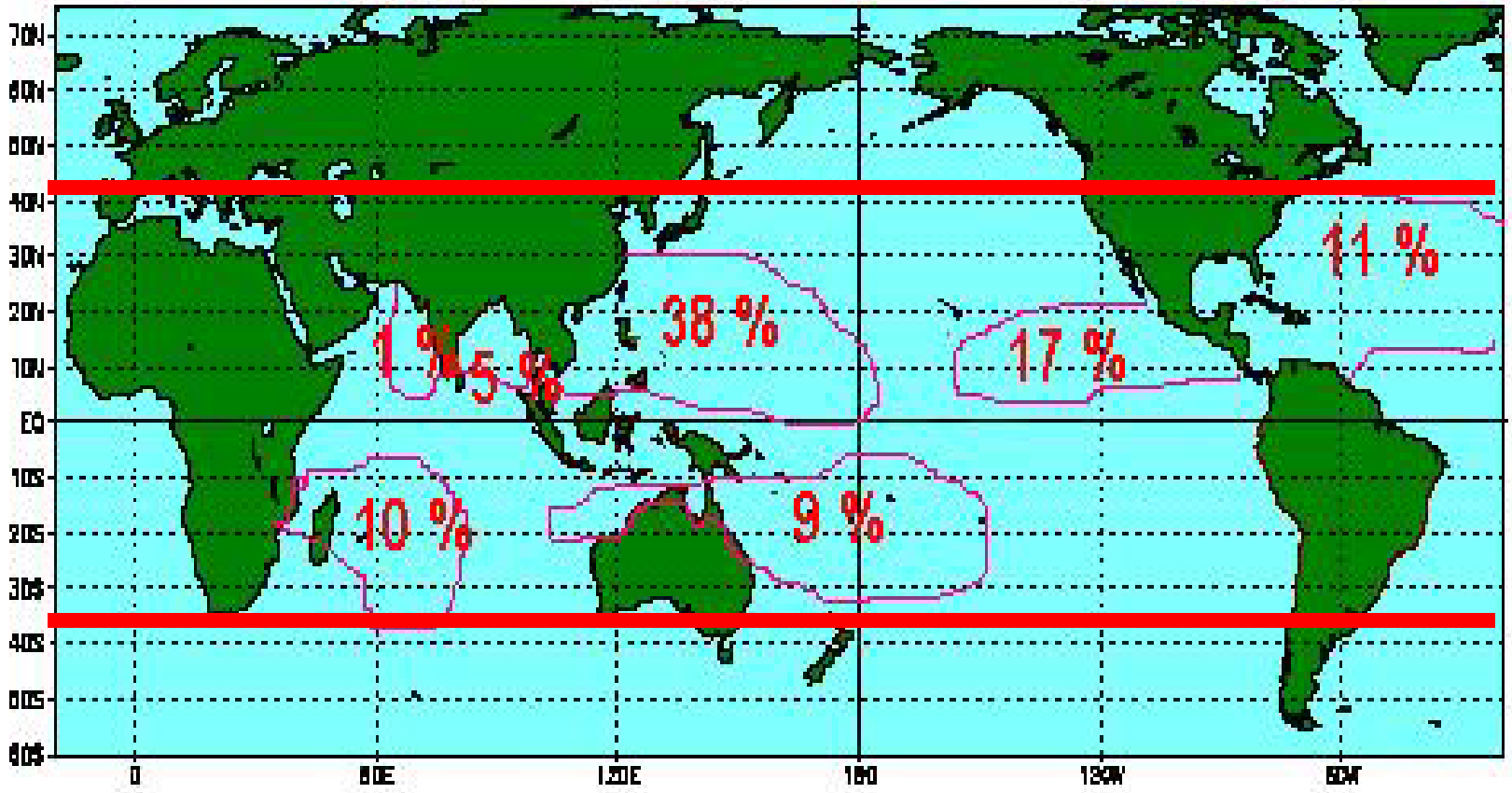
**Dr. José Rubiera**
**National Forecasting Center**
**Instituto de Meteorología, Cuba**

**Thematic Session Cluster 2**
**World Conference on**
**Disaster Reduction**
**Kobe, Japan, January 18 – 22, 2005**

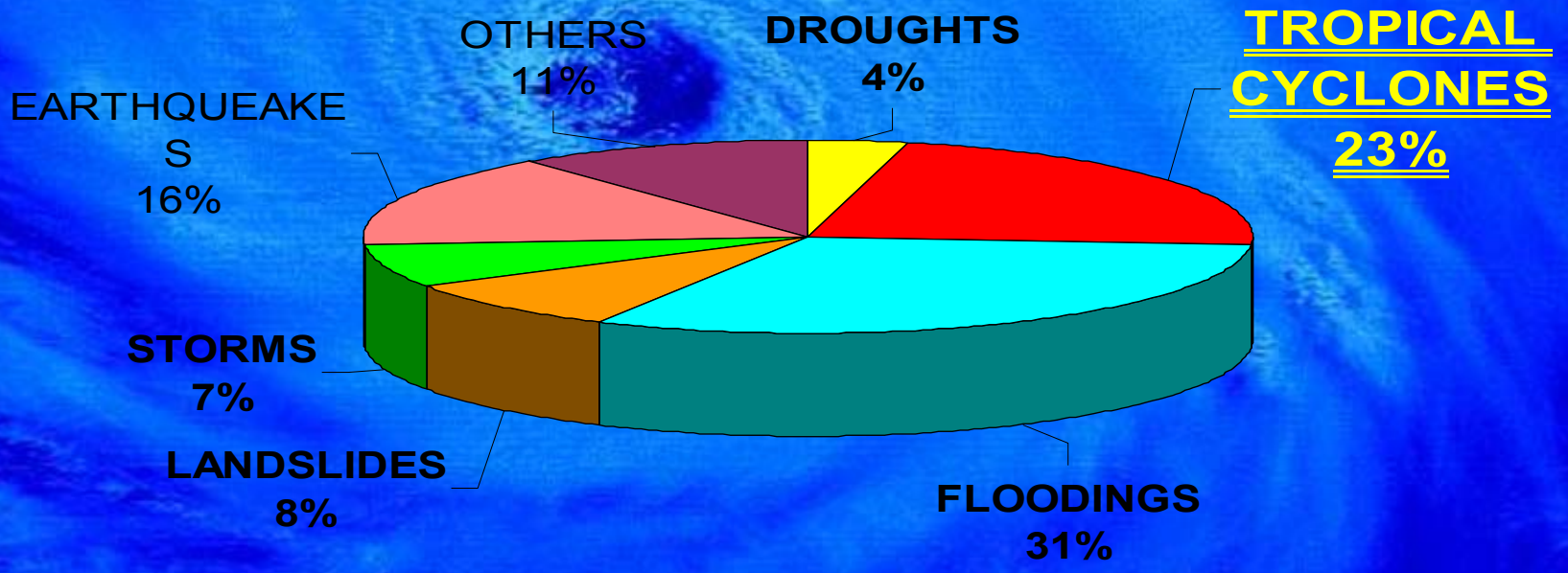
# TROPICAL CYCLONE

- A WARM-CORE LOW PRESSURE WEATHER SYSTEM
- DEVELOPS OVER TROPICAL OR SUBTROPICAL OCEANS
- HAS AN ORGANIZED CIRCULATION OF WINDS
- ARE CLASSIFIED ACCORDING TO THE SPEED OF ITS MAXIMUM SUSTAINED WINDS

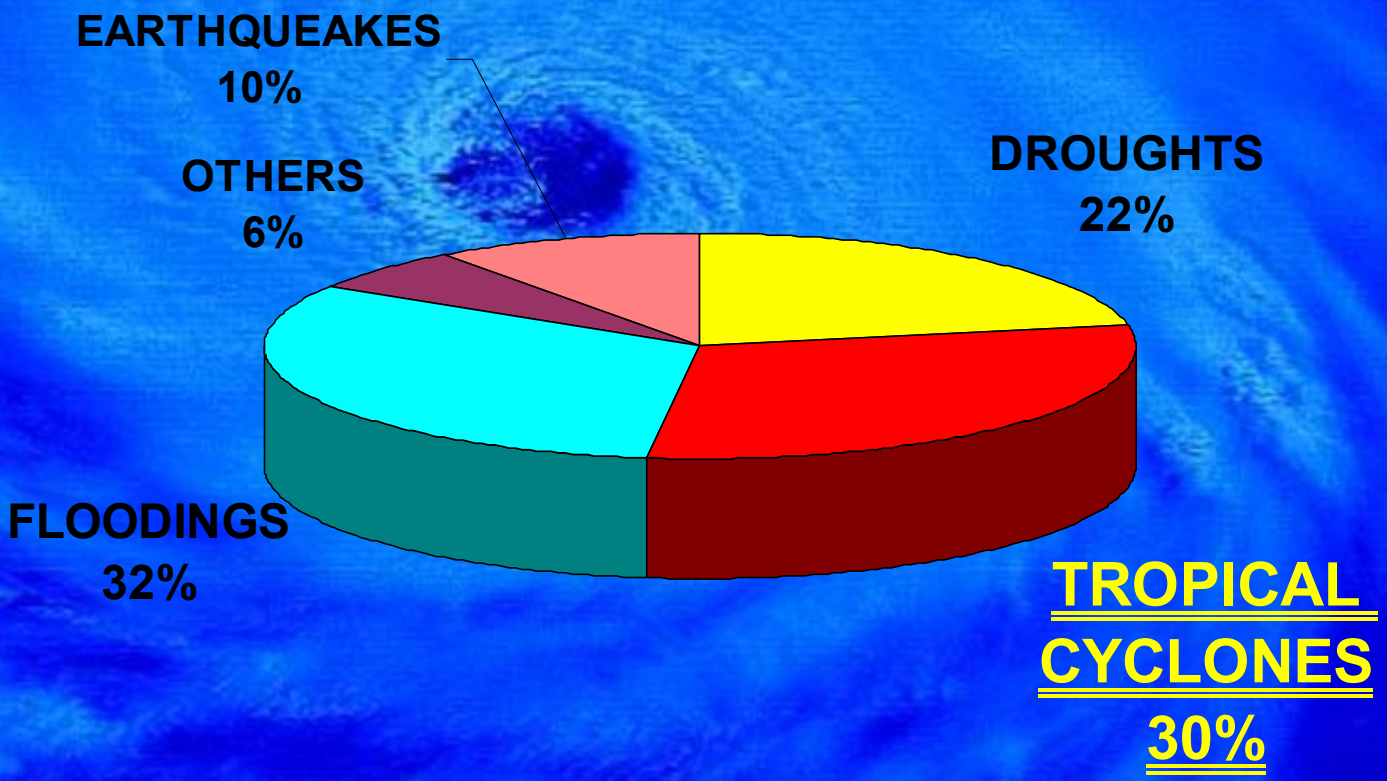
# WORLD DISTRIBUTION OF TROPICAL CYCLONES



# DEATHS IN NATURAL DISASTERS



# MATERIAL LOSSES IN NATURAL DISASTERS



# CLASIFICATION OF TROPICAL CYCLONES IN WMO RA IV HURRICANE COMMITTE COUNTRIES

| | |
|---|---|
| **Tropical Depression** | **< 63 km/h** |
| **Tropical Storm** | **63 - 117 km/h** |
| **Hurricane** | **> = 118 km/h** |

# CLASSIFICATION SCALE FOR HURRICANES IN WMO RA-IV

## THE SAFFIR-SIMPSON SCALE

| *Category* | *Maximum Sustained Winds (km/h)* | *Potential Damage* |
|---|---|---|
| **1** | 118-153 | Minimal |
| **2** | 154-177 | Moderate |
| **3** | 178-209 | Extensive |
| **4** | 210-250 | Extreme |
| **5** | > 250 | Catastrophic |

MAJOR HURRICANES

DATA INPUT

ANALYSIS AND NUMERICAL MODELS

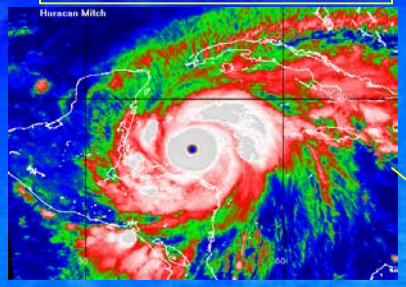
OFFICIAL FORECASTS AND WARNINGS

DIFUSSION OF WARNINGS

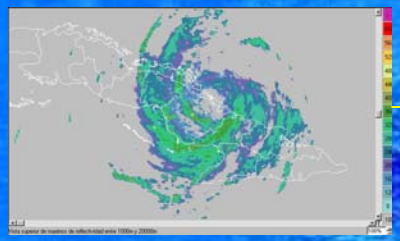
RESPONSE ACTIONS

GOVERNMENT, CIVIL DEFENSE, RESIDENTS

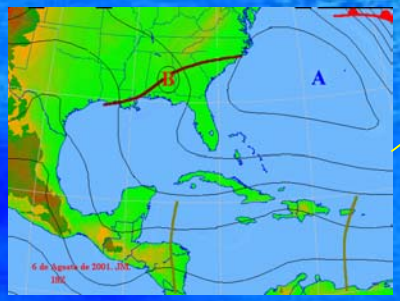
SATELLITES



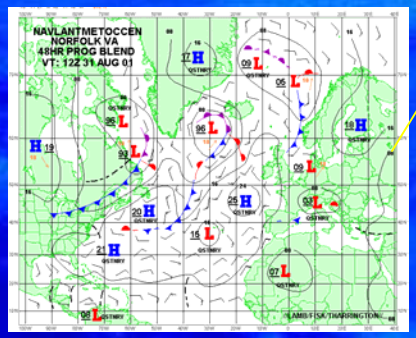

RADARS



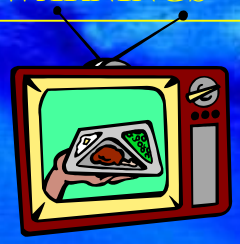
WEATHER STATIONS
UA SOUNDINGS
SHIPS
BUOYS
AIRCRAFTS



NUMERICAL MODELS




FORECASTERS



TV

RADIO

PHONE - FAX

INTERNET

# The Hurricane Forecast Process

## DATA ACQUISITION:

- Surface observations (land, ships, buoys).
- Upper air observations (rawinsondes, aircrafts).
- Satellites (geostationary, polar).

## NUMERICAL GUIDANCE:

- Global Models
- Regional Models
- TC track and intensity Models

## THE PROCESS OF DECISION MAKING

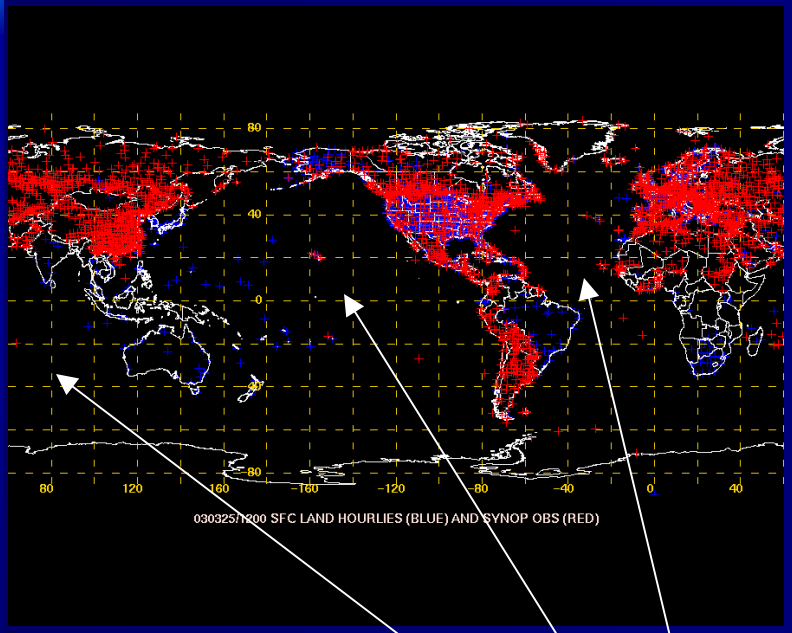
- Model Comparison, Probabilities, Consensus.

## THE WARNING PROCESS

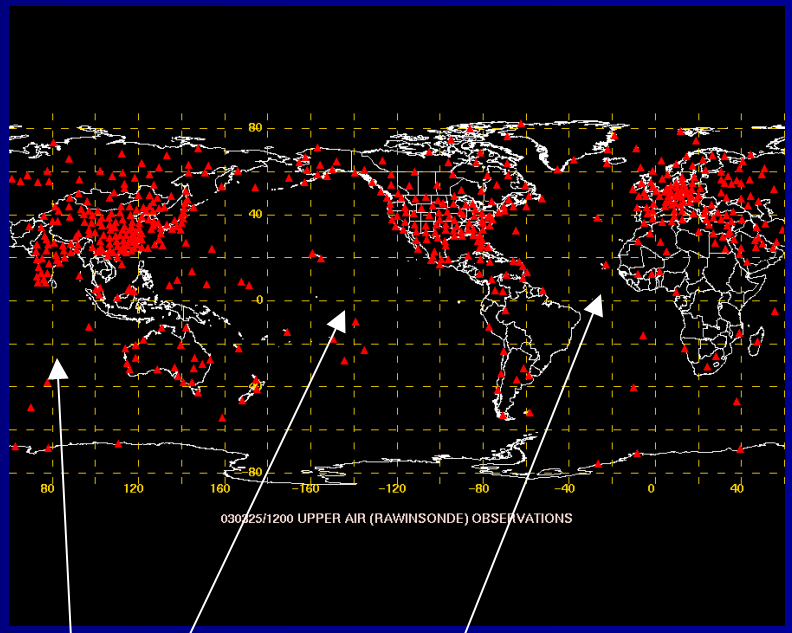
- Issuance and Difusion of Warnings

# A MAJOR SHORTCOMING FOR HURRICANE FORECASTING: THE LACK OF OBSERVATIONS OVER THE OCEANS

Surface Obs.

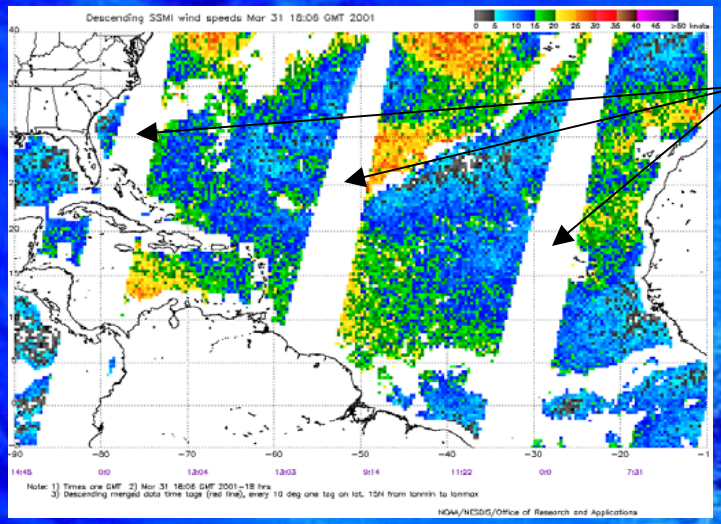



Upper Air Obs.



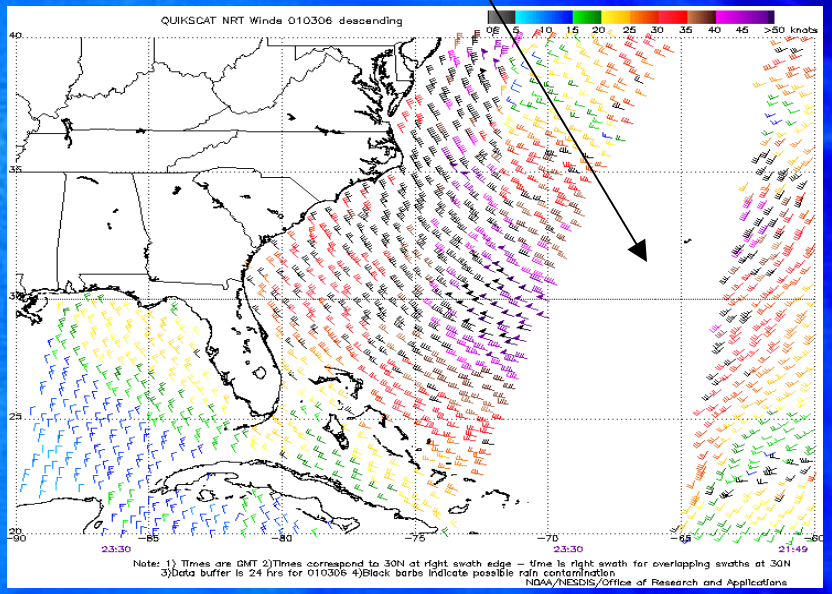

Look at the Gaps over the Oceans

# SATELLITES DERIVED DATA COULD HELP TO SOLVE THIS PROBLEM, BUT IT IS NOT ENOUGH!

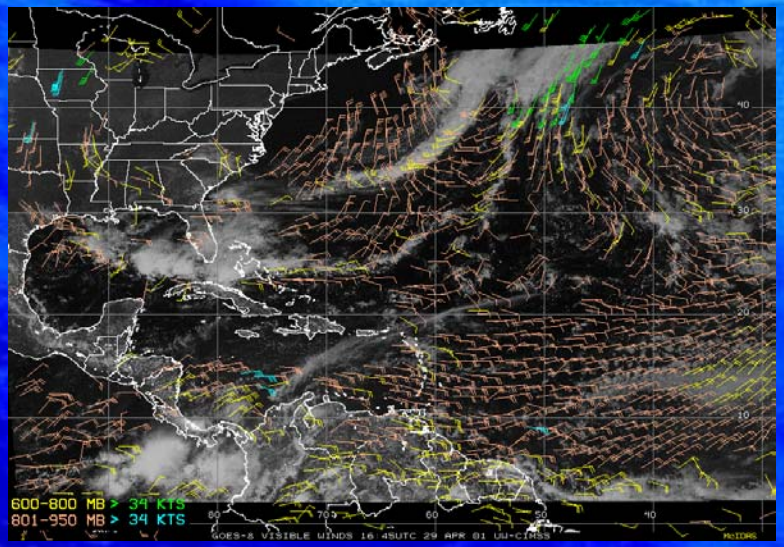



SSMI

Data gaps between swaths largest over the tropics



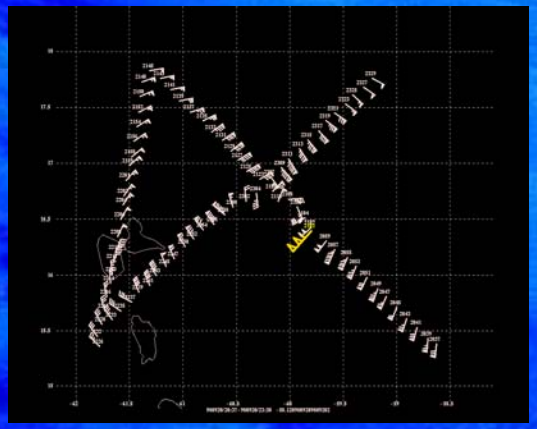

SeaWinds on QuickScat



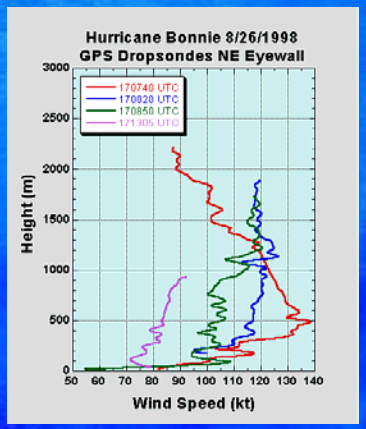

Satellite derived Winds

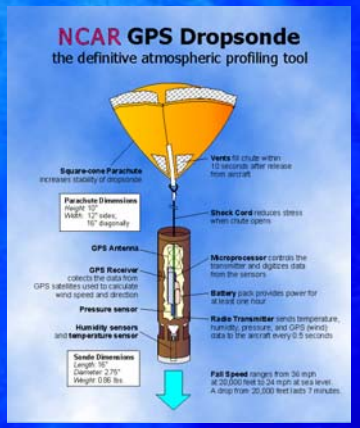
# AIRCRAFT RECONNAISANCE

Helps in gathering more data…but it's still not enough!.



ACTUAL WINDS PATTERN




GPS DROPSONDES

# FORECAST MODEL ERRORS

## INICIALIZATION

- Deficient Observational networks and data assimilation methods
- Initial observations not available at every point and cannot be measured to an infinite degree of precision.
- Errors are likely largest in areas of sparse data.

## INTEGRATION

- Initial condition errors grow with integration time, most rapidly at smaller scales.
- Model resolution is insufficient.
  - Parameterization required. Various parameterizations/physics available.
- Model equations do not fully represent all processes.
  - Lack of understanding of the processes themselves.
  - Lack of computational resources.

# ERRORS ARE GREATER WHEN FORECAST RANGE INCREASES…..

| | FORECAST RANGE (hr); ERROR (km) | | | | |
|---|---|---|---|---|---|
| MODEL | 12 | 24 | 36 | 48 | 72 |
| CLIPER | 51 | 103 | 161 | 220 | 351 |
| BAMS | 61 | 114 | 168 | 222 | 336 |
| BAMN | 49 | 91 | 133 | 177 | 268 |
| BAMD | 47 | 88 | 132 | 183 | 293 |
| LBAR | 41 | 75 | 111 | 159 | 284 |
| GFDI | 42 | 69 | 98 | 128 | 200 |
| AVN | 56 | 98 | 139 | 178 | 248 |
| NOGAPS | 57 | 81 | 107 | 126 | 193 |
| UKMET | 57 | 92 | 136 | 165 | 244 |
| GFDL | 44 | 70 | 96 | 120 | 178 |

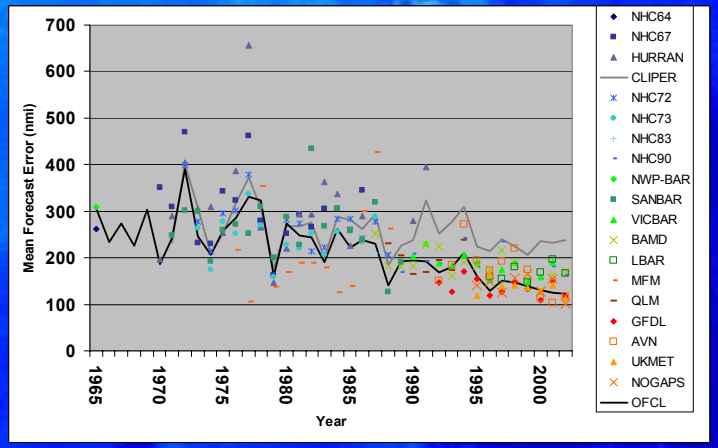
TRACK FORECAST MODELS

**TRACK FORECASTS ARE MUCH BETTER THAT INTENSITY FORECASTS**

| | FORECAST RANGE (hr); ERROR (km/h) | | | | |
|---|---|---|---|---|---|
| MODEL | 12 | 24 | 36 | 48 | 72 |
| SHIFOR | 8.2 | 11.4 | 14.0 | 16.9 | 21.1 |
| SHIPS | 8.1 | 11.0 | 13.0 | 15.7 | 20.5 |
| GFDI | 9.3 | 11.6 | 13.9 | 16.6 | 19.0 |
| CT91CI | 10.0 | 13.2 | 16.0 | 17.8 | 20.6 |

INTENSITY FORECAST MODELS

**HOWEVER, ERRORS ARE DIMINISHING IN ALL TIME RANGES DUE TO IMPROVEMENT IN DATA ASSIMILATION AND MODEL PHISICS.**



# OPTIONS TO REDUCE FORECAST UNCERTAINTY?

- More accurate and numerous observations with greater coverage.
- Improved analysis (data assimilation) methods.
- Faster computers and more complex models.
- ***Probabilistic forecasting with ENSAMBLES and a CONSENSUS FORECAST***

# Model Forecasting Definitions

***Deterministic*** - single forecast from a single initialization

***Ensemble*** - collection of forecasts verifying at the same time and created from different but equally viable initial conditions, forecasting methods, and/or models that (ideally) statistically represent nearly all forecast possibilities

***Consensus*** - average of multiple forecasts verifying at same time

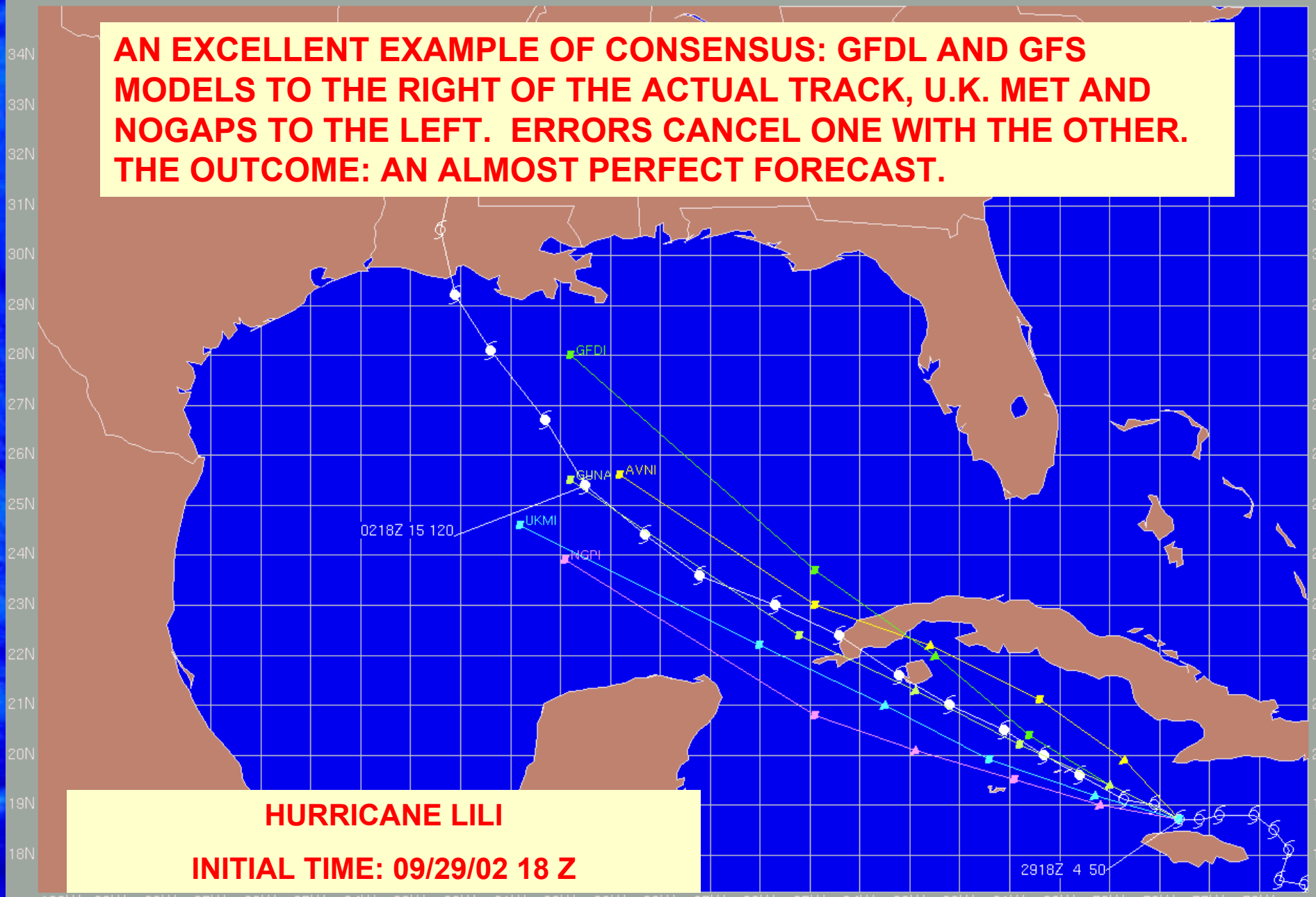
***Lagged Average*** - average of forecasts with different initial times and all verifying at the same time

***Superensemble*** - multiple models and multiple initializations, adjusted for biases

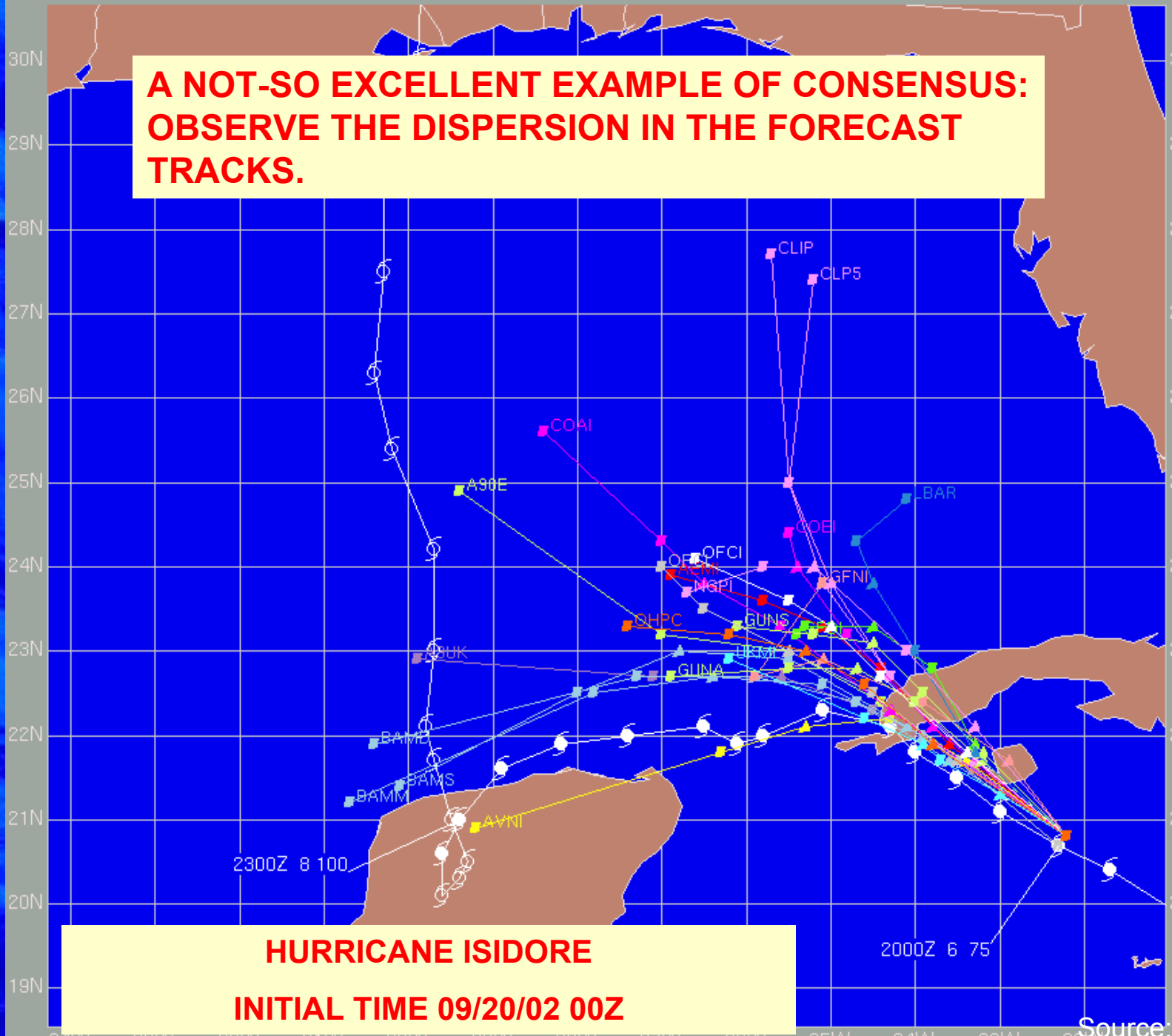
# TRACK FORECAST MEAN ERRORS FOR THE NORTHWESTERN PACIFIC, TAKING A CONSENSUS OF MODELS AND INDIVIDUAL MODELS

| Forecast Range (hrs) | 24 | 48 | 72 | 96 | 120 |
|---|---|---|---|---|---|
| CONSENSUS ERROR (km) | 128 | 216 | 289 | 387 | 503 |
| INDIVIDUAL MODELS ERRORS (km) | 140 - 181 | 240 – 303 | 335 – 449 | 435 – 527 | 592 - 666 |

(Source: Davidson, N.E., 2003)




Source: TCP/NHC


A NOT-SO EXCELLENT EXAMPLE OF CONSENSUS: OBSERVE THE DISPERSION IN THE FORECAST TRACKS.
CLIP
CLP5
COAI
A90E
LBAR
OBI
OFCI
GFNI
GUNS
UKMI
GUNA
BAMD
BAMS
BAMM
AVNI
2300Z 8 100
2000Z 6 75
HURRICANE ISIDORE
INITIAL TIME 09/20/02 00Z
Source: TCP/NHC

# THE CHALLENGE OF AN EARLY WARNING IN HURRICANES

**MEAN 5-DAY TRACK FORECAST ERRORS FOR THE ATLANTIC BASIN**

**24 HR….147 km**

**48 HR….257 km**

**72 HR….388 km**

**96 HR….505 km**

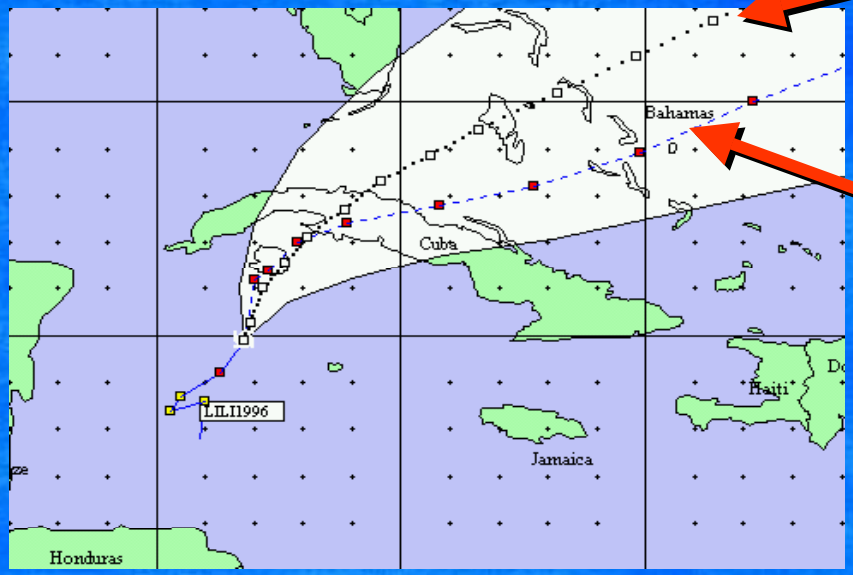
**120 HR…688 km**




Source: TCP/NHC

# ERROR CONE GRAPHICS

## Forecast track + mean error = "Risk area"




Forecasted mean track in the middle of the cone

Actual best track

**(60 to 70 % of actual tracks will be inside the cone area)**

**Main Application in Early Warning:**
**To make users aware of the uncertainty of the forecast track and to discourage users from focusing only on a single forecast track, but at the same time <u>ASSESSING THAT THEY ARE IN AN AREA AT RISK.</u>**

# "*WARNING*" AND "*EARLY WARNING*" HAS DIFFERENT MEANINGS WHEN DEALING WITH TROPICAL CYCLONES

## WARNING

- Usually means that inmediate actions have to be taken to protect lives and properties, generally in a 24 hr time frame.

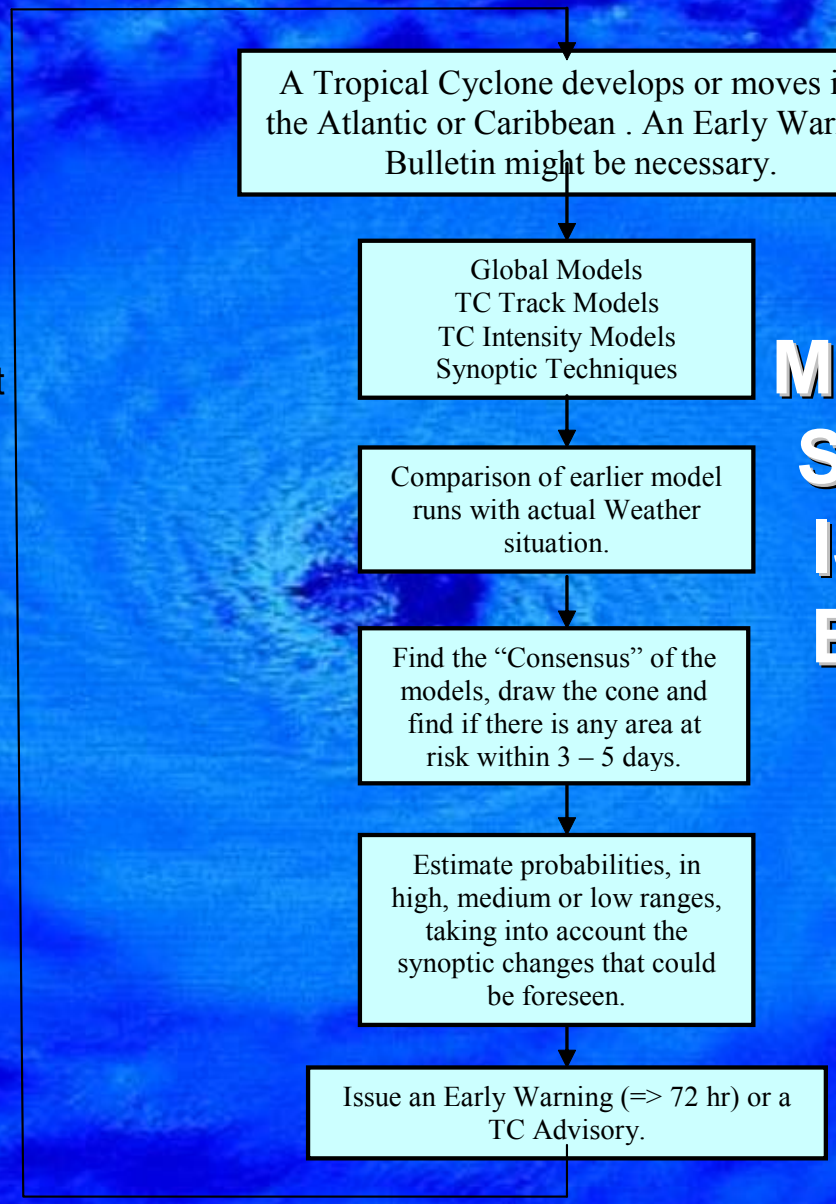
## EARLY WARNING

- Means that **there is some likelihood that hurricane conditions might be expected in 3, 4 or 5 days and, because of it, the level of information and awareness should be increased, without taking, for the moment, any further action.** This information is given with time enough, so that everyone could be well informed.

- Heavily depends on a previous education and preparation of the users of this information (i.e. Government, Civil Defense, the Media people, residents, etc.).

- Increases awareness on the likelihood of the hurricane threat and prepares everybody to take actions in the near future, if it becomes necessary.

# METHODOLOGICAL SCHEME FOR THE ISSUANCE OF AN EARLY WARNING AT CUBAN NATIONAL FORECASTING CENTER.



# EXAMPLE OF AN EARLY WARNING BULLETIN

- Havana, Thursday, November 1, 2001 2:30 pm
  National Forecasting Center, Institute of Meteorology.

- **EARLY WARNING BULLETIN**

  **Synopsis**: Tropical Depression No. 15 was upgraded to Tropical Storm "Michelle" last night and is now over water in the NW Caribbean Sea. The Tropical Storm is located 490 km South of Cabo Corrientes, Pinar del Río province. Maximum Sustained Winds are 110 km/h, near Hurricane strengh. It is expected to become a Hurricane this afternoon. It is moving Northnorthwest ay 11 km/h.

- **Outlook**: Conditions favor further development of this tropical system. Within 72 hours, "Michelle" could already be a Major Hurricane over an area very near Cuba. A Northnortheast or Northeast movement is likely to occur in 72 hours. That movement would make "Michelle" cross directly over Cuba. The most threatened areas are the Western and Central provinces. The greatest likelihood is for a hit from Sunday to Monday. This will depend on the storm movement, for there could be periods of stalling or slow movement before "Michelle" speeds up in a near Northeast direction.
  All interests should very carefully follow further information on "Michelle" issued by the National Forecasting Center.

# EXAMPLES OF THE USE OF THE CONE GRAPHICS IN CUBAN TV DURING THE APPROACH OF HURRICANE GEORGES (1998)


CIUDAD DE LA HABANA, MIERCOLES 23 DE SEPTIEMBRE DE 1998
AÑO DEL ANIVERSARIO 40 DE LAS BATALLAS DECISIVAS DE LA GUERRA DE LIBERACION

AÑO 34 / NUMERO 190
CIERRE: 12:30 A.M. / 20 CTVS.

Granma

ORGANO OFICIAL DEL COMITE CENTRAL DEL PARTIDO COMUNISTA DE CUBA

# Toman medidas emergentes ante potencial peligro por la aproximación del huracán Georges

**Activados todos los Puestos de Dirección de los Consejos de Defensa en las provincias con peligro. Orienta la Defensa Civil las medidas para proteger a la población y los recursos de la economía. Analiza Meteorología la trayectoria y características del huracán que azota el Caribe. Causan numerosos estragos la fuerza de los vientos**

**EXAMPLE OF THE USE OF THE CONE GRAPHICS IN NEWSPAPERS DURING THE APPROACH OF HURRICANE GEORGES**


*La gráfica muestra las perspectivas de trayectoria del centro de Georges para las próximas 72 horas, según diferentes modelos de pronósticos. La mayoría de los modelos coincide en la variante de la costa norte, sin embargo otros muestran un movimiento más al sur.*

## Una amenaza inminente

■ **Doctor José Rubiera, jefe del Departamento de Pronósticos del Instituto de Meteorología, CITMA, especial para Granma**

El huracán Georges concretará hoy su amenaza a las provincias orientales de nuestro país. Se ha previsto que desde temprano se deterioren las condiciones, comenzando por el extremo oriental y avanzando el mal tiempo hacia el occidente, en que se irán implantando los nublados y lluvias que acompañan a Georges en su peregrinar por las Antillas Mayores. Se incrementarán también los vientos y las marejadas, con peligro para la navegación en el Paso de los Vientos y ambas costas orientales.

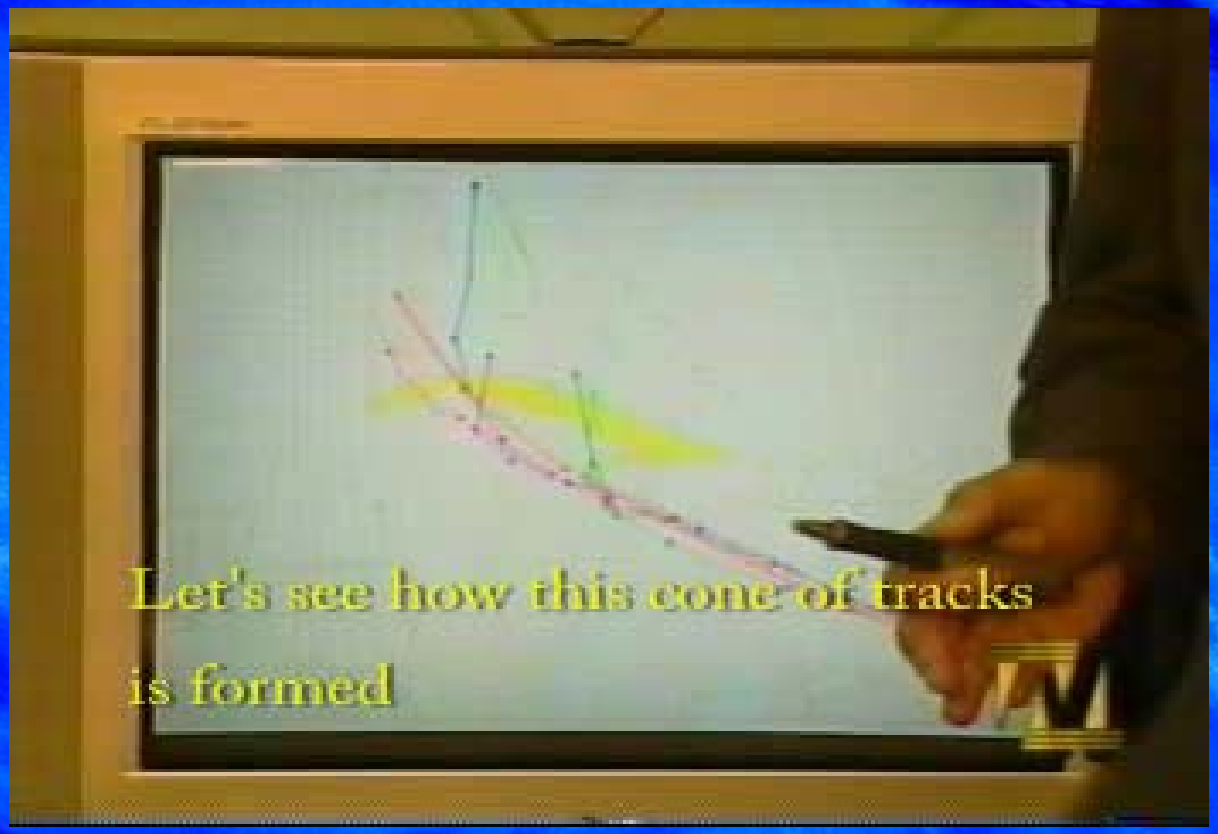
La trayectoria del centro prevista con mayor probabilidad (ver gráfico) cruza durante el día de hoy por la porción norte de Guantánamo y Holguín, sobre tierra o por el mar muy próximo a la costa norte, y mañana cerca de la costa norte de Camagüey y Ciego de Avila, para después inclinarse más al noroeste. Pero que la trayectoria del centro pase algo más allá o acá tiene una importancia solo relativa; lo más importante es que el huracán no es un punto ni su trayectoria se traza con una línea, sino que es una amplia zona de influencia que en el caso de Georges alcanza de 200 a 300 kilómetros de diámetro.

Hay que destacar que Georges se debilitó a su paso por la República Dominicana y Haití, la tierra de montañas más altas del Caribe con alturas que llegan a poco más de 3 000 metros. Pero mantiene una estructura circular y, al salir el centro al mar quedando sobre este parte de su circulación, es muy probable que gane nuevamente en fuerza.

Así que lo más recomendable es seguir en todo momento las orientaciones de la Defensa Civil junto a las informaciones que emite nuestro Departamento de Pronósticos del Instituto de Meteorología. Es la única manera de salvar vidas y minimizar los daños. Cuando el Lili se logró, y estamos seguros que en este caso, o cualquier caso futuro, también.

(página 8)

# AN EXAMPLE OF HOW AN EARLY WARNINGS MESSAGE IS BROADCAST THROUGH CUBAN TV




"Live" TV broadcast from the National Forecasting Center Sept 9, 2004. Hurricane "Ivan" affected Western Cuba on Sept. 13, 2004

# LAST 9 YEARS OF ACTIVE HURRICANE SEASONS IN CUBA

| NAME | YEAR | CAT | EVACUATED | ECONOMIC LOSSES (millions USD) | CASUALTIES |
|---|---|---|---|---|---|
| LILI | 1996 | 2 | 421 200 | 362 | 0 |
| GEORGES | 1998 | 1 | 818 800 | 306 | 6 |
| MICHELLE | 2001 | 4 | 783 400 | 1 866 | 5 |
| ISIDORE | 2002 | 1 | 307 000 | 713 | 0 |
| LILI | 2002 | 2 | 385 300 | | 1 |
| CHARLEY | 2004 | 3 | 224 449 | 923 | 4 |
| IVAN | 2004 | 5 | 2 266 068 | 1 223 | 0 |
| ***TOTAL*** | | | 5 272817 | 5 393 | 16 |

# THANK YOU !

# MUCHAS GRACIAS !