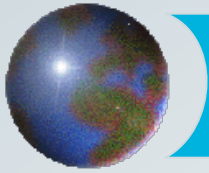


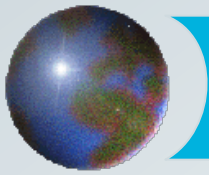
Hurricanes and Weather Prediction

GEOG/ENST 2331 – Lecture 20
Ahrens: Chapters 15 and 13



Last lecture

- ✦ Tropical cyclone definitions
- ✦ Hurricane dynamics
 - ✦ Formation
 - ✦ Structure
 - ✦ Movement
 - ✦ Dissipation



Lecture outline

✚ **Hurricane climatology**

- ✚ **Forecasting**

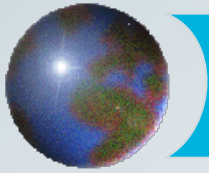
- ✚ **Hurricanes and Canada**

✚ **Modelling in forecasting**

- ✚ **Patterns**

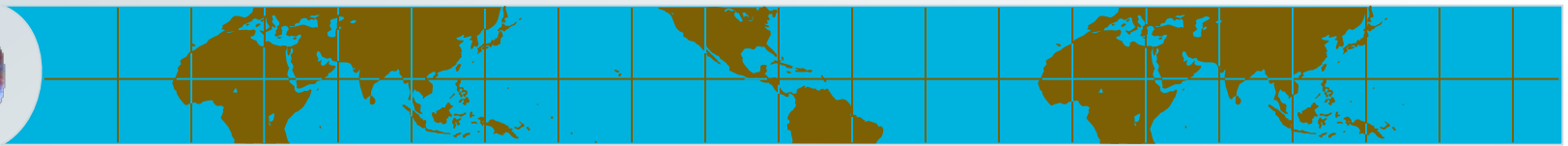
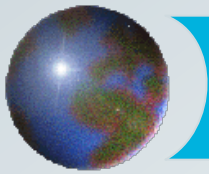
- ✚ **Model runs**

- ✚ **Progs**



Lifespan of a tropical cyclone

- ✦ SST
- ✦ Upper wind structure
 - ▣ El Niño
 - ▣ QBO
- ✦ Landfall



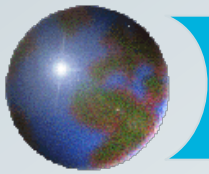
Forecasting Atlantic Hurricanes

- ✦ Colorado State University (**CSU**)
 - ✦ Formerly the Gray Index
- ✦ Tropical Storm Risk (**TSR**)
- ✦ National Oceanic and Atmospheric Administration (**NOAA**)

- ✦ Seasonal factors
 - ✦ ENSO (El Nino-Southern Oscillation)
 - ✦ QBO (Quasi-biennial Oscillation)
 - ✦ SSTs (sea surface temperatures)
 - ✦ Sahel rainfall

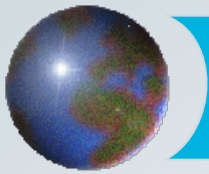


Dr. William Gray



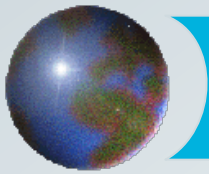
CSU: ATLANTIC BASIN SEASONAL HURRICANE FORECASTS FOR 2004

Forecast Parameter	Dec	Apr	May	Aug	Sep	Oct	2004
Named Storms (9.6)	13	14	14	13	16	15	14
Hurricanes (5.9)	7	8	8	7	8	9	8
Intense Hurricanes (2.3)	3	3	3	3	5	6	6

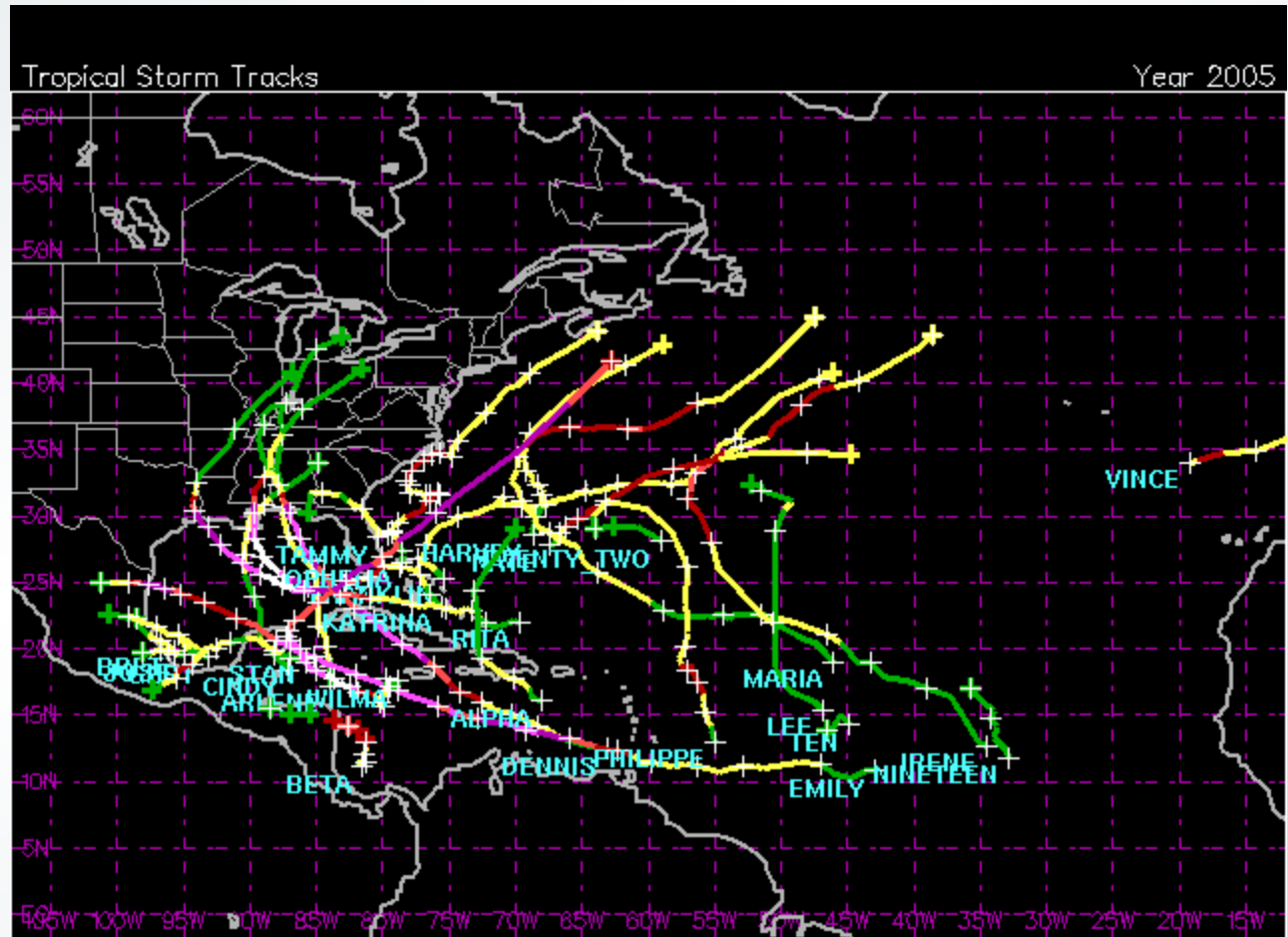


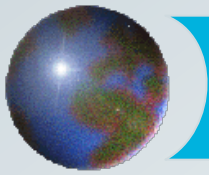
CSU: ATLANTIC BASIN SEASONAL HURRICANE FORECAST FOR 2005

	Dec	April	June	2005
Named Storms (9.6)	11	13	15	27
Hurricanes (5.9)	6	7	8	15
Intense Hurricanes (2.3)	3	3	4	7



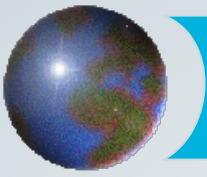
2005 Hurricane season



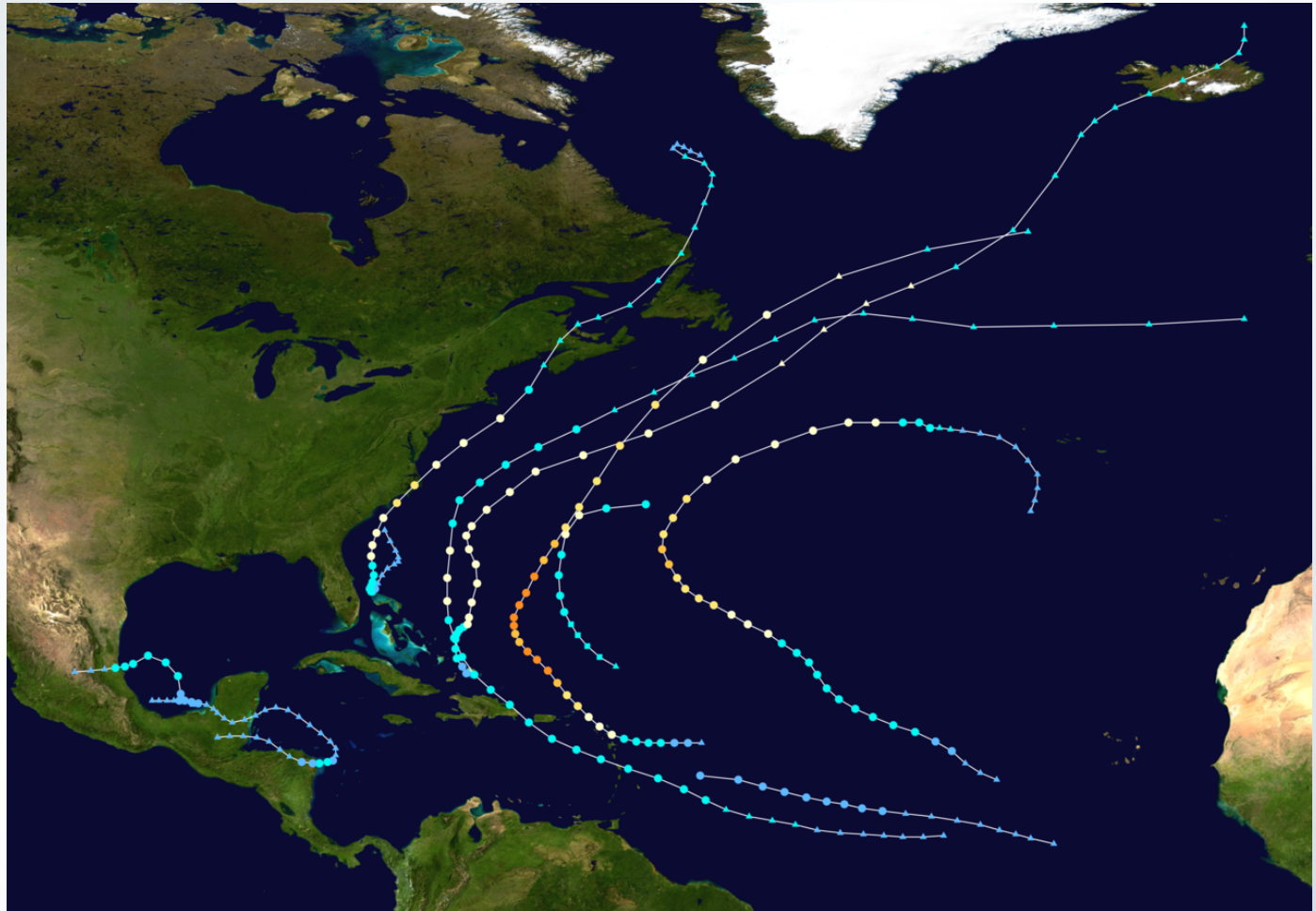


CSU Forecasting

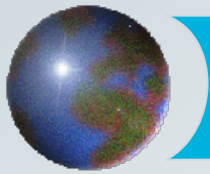
- ✚ 2005 – poorest forecast on record for Atlantic tropical storms
 - ✚ NOAA forecast was similarly poor
- ✚ 2006 – forecast number was far too *high*
- ✚ 2013 – too high again; “biggest bust” in CSU history



2014 Atlantic Hurricanes

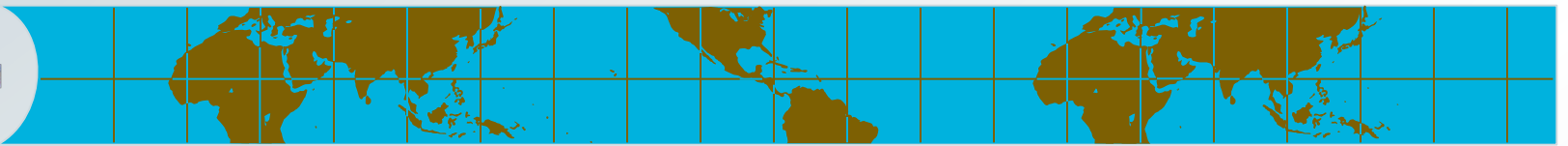
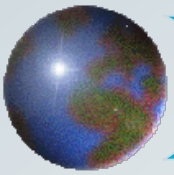


Source: Wikipedia

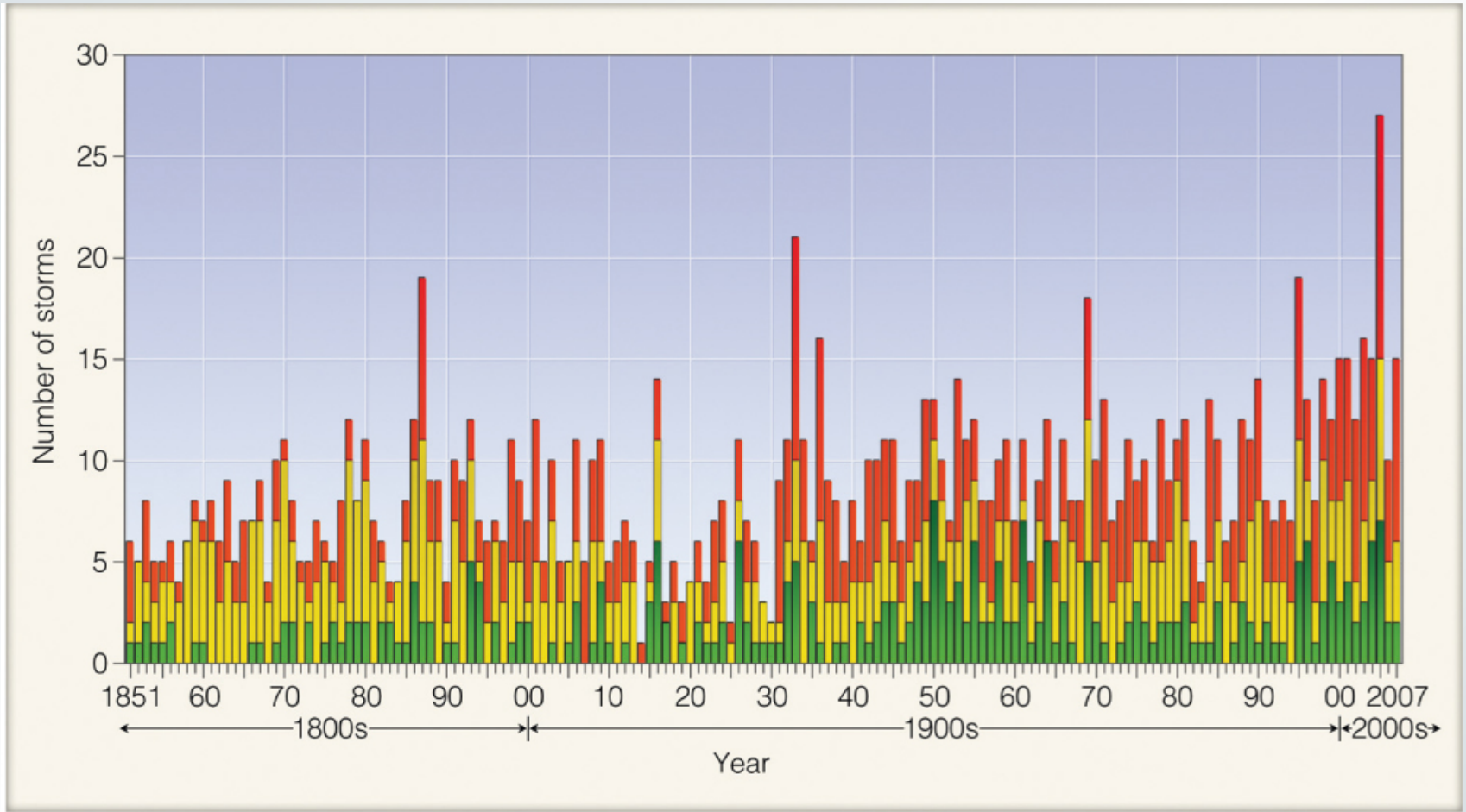


2014 Forecasts

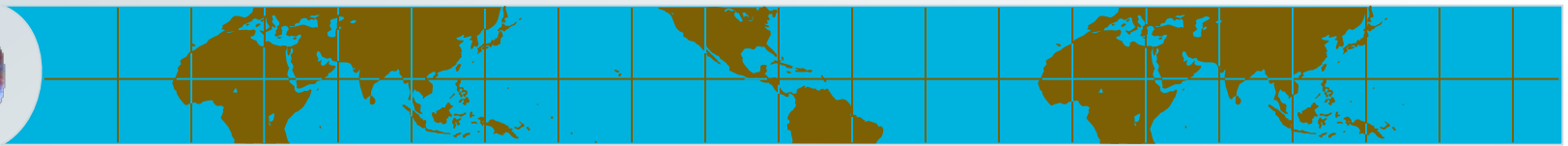
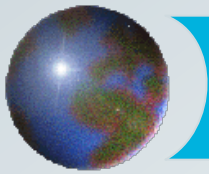
Forecast Month	Source	Named Storms	Hurricanes	Major Hurricanes
Climatology	1950-2000	9.6	5.9	2.3
Climatology	1981-2010	12.1	6.4	2.7
April	TSR	12	5	2
April	CSU	9	3	1
May	NOAA	8-13	3-6	1-2
July	CSU	10	4	1
Observed	2014	8	6	2



Atlantic Hurricanes

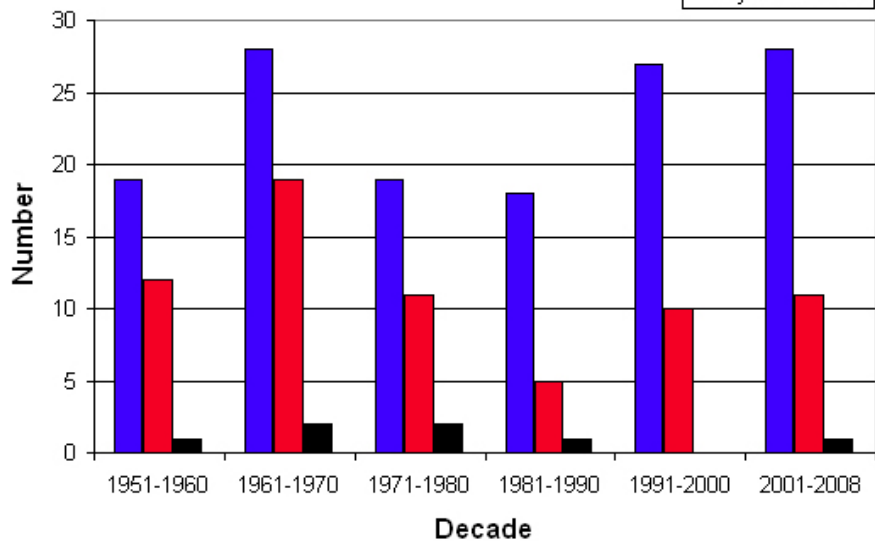


Ahrens: Fig. 7, p. 482

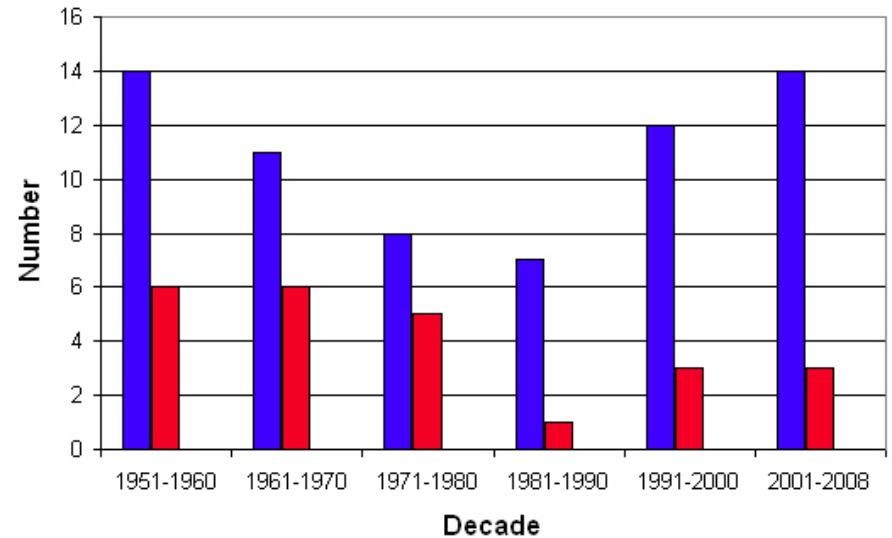


Canadian Hurricanes

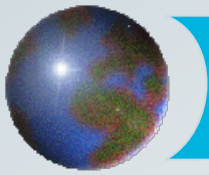
**Number of Atlantic Tropical Cyclones
in Canadian Marine Areas**



**Number of Atlantic Tropical Cyclones
Making Landfall in Canada**

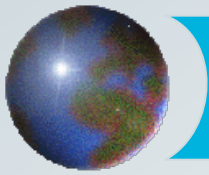


Source: Canadian Hurricane Centre



Hurricanes and climate change

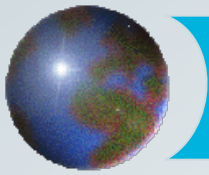
- ✚ 2001-2005 was the most active 5-year period ever for Atlantic Hurricanes
- ✚ Global warming is not predicted to bring increased tropical cyclone incidence
 - ✚ May bring more intense cyclones
 - ✚ May bring longer cyclone seasons



Climate change

- ✦ Opposing factors at work:
 - ✦ Higher SST *should* result in more – and more powerful – cyclones
 - ✦ Greater stability in tropical troposphere *should* result in fewer storms

- ✦ May combine for fewer but more powerful cyclones
 - ✦ Some studies predict greater numbers in the North Atlantic specifically



Hurricane Sandy

📍 October 25, 2013

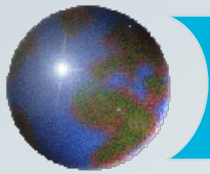
- 📍 Sandy peaks at Category 3
- 📍 Landfall in Cuba

📍 October 30

- 📍 Tropical storm
- 📍 Landfall in New Jersey



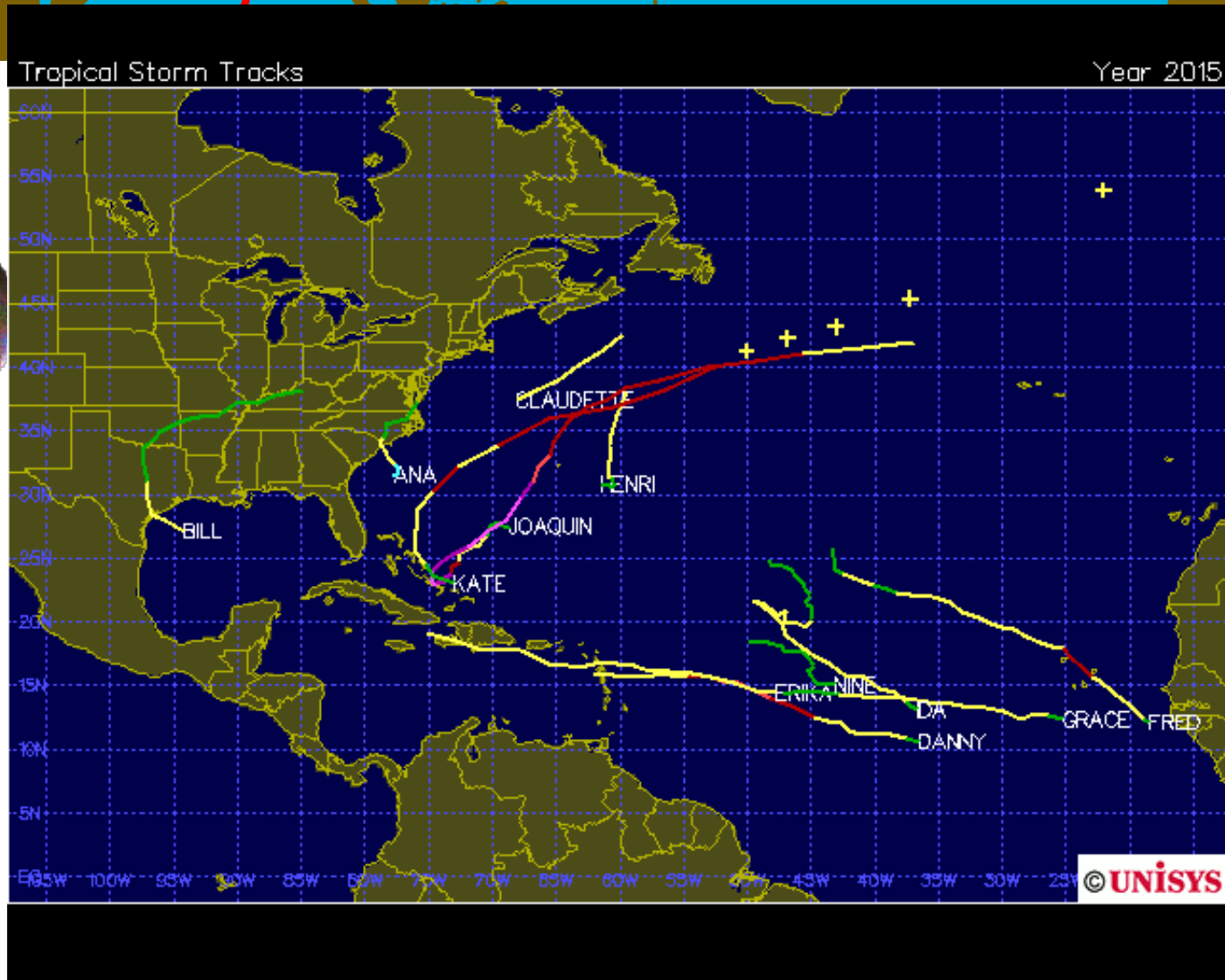
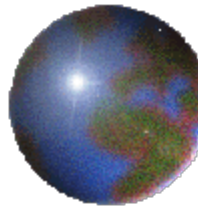
Hurricane Sandy

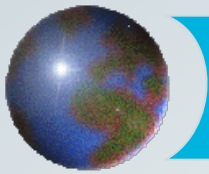


European Centre for Medium-Range Weather Forecasts

- ✦ Independent intergovernmental organisation
- ✦ Supported by 21 European Member States
- ✦ World's largest archive of numerical weather prediction data
- ✦ Global weather forecasts to 15 days and seasonal forecasts to 12 months
- ✦ prediction of Hurricane Sandy in October 2012 making landfall on the East Coast of the United States seven days before it happened

Tropical Storm tracks 2015

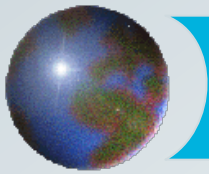




Hurricane-strength storms: 2015 compared to average

Basin	1 an 2	3 to 5	Total	Average
Atlantic	2	2	4	5.9
NH East Pacific*	6	10	15	9.0
NH West Pacific*	5	19	22	16.9
NH Indian	0	2	2	2.2
SH Indian	3	2	5	10.3
SH West Pacific	3	2	5	4.8
* Active TS Global	19	37	56	48.3

To Nov. 24, 2015 Sources: Unisys; A&B Table 12-1



Brief history of Hurricane names

Caribbean

Clement Wragge

WW 2 in Pacific

World Meteorological Organization (WMO) in 1953

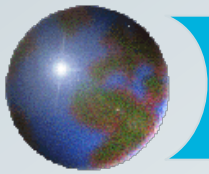
➤ tropical storms female names: alphabetical order from the beginning of each year

1978, 1978

➤ alternately male and female names

➤ Six semi-permanent lists of names

Retired names



2015

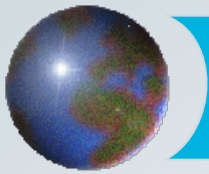
Ana
Bill
Claudette
Danny
Erika
Fred
Grace*
Henri
Ida
Joaquin
Kate*
Larry
Mindy
Nicholas
Odette
Peter
Rose
Sam
Teresa
Victor
Wanda

2016

Alex
Bonnie
Colin
Danielle
Earl
Fiona
Gaston
Hermine
Ian
Julia
Karl
Lisa
Matthew
Nicole
Otto
Paula
Richard
Shary
Tobias
Virginie
Walter

Hurricane names

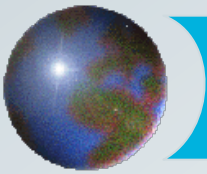
- ✦ Six lists are used in rotation and re-cycled every six years, i.e., the 2015 list will be used again in 2021.
- ✦ If 21 named tropical cyclones occur in the Atlantic basin in a season, the Greek alphabet is used for additional storms.
- ✦ **Grace*** (1991) was the hurricane associated with the “perfect storm” and film
- ✦ **Kate***: likely the final Atlantic hurricane of the 2015 season.



Atlantic Hurricane 2015

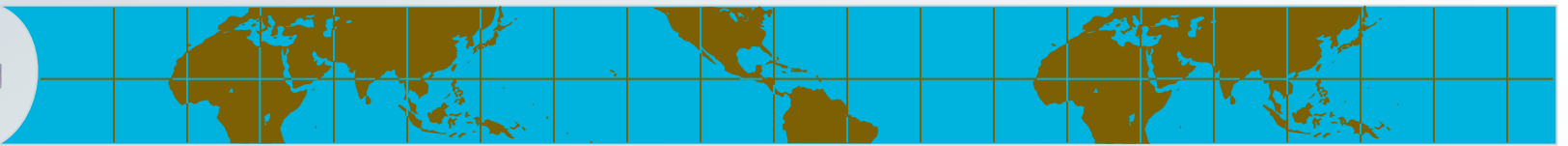
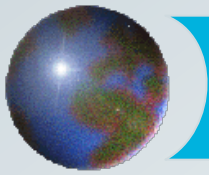
#	Name	Date	Wind (knots)	Cat
1	TS ANA	08-11 MAY	40	
2	TS BILL	16-20 JUN	50	
3	TS CLAUDETTE	13-14 JUL	45	
4	Hurr-3 DANNY	18-24 AUG	100	3
5	TS ERIKA	25-29 AUG	45	
6	Hurr-1 FRED	30 AUG-06 SEP	75	1
7	TS GRACE	05-09 SEP	45	
8	TS HENRI	09-11 SEP	35	
9	T D NINE	16-19 SEP	30	
10	TS IDA	18-27 SEP	45	
11	Hurr-4 JOAQUIN	28 SEP-08 OCT	135	4
12	Hurri-1 KATE	09-12 NOV	65	1

Tropical storm Sandra presently in Eastern Pacific . . .

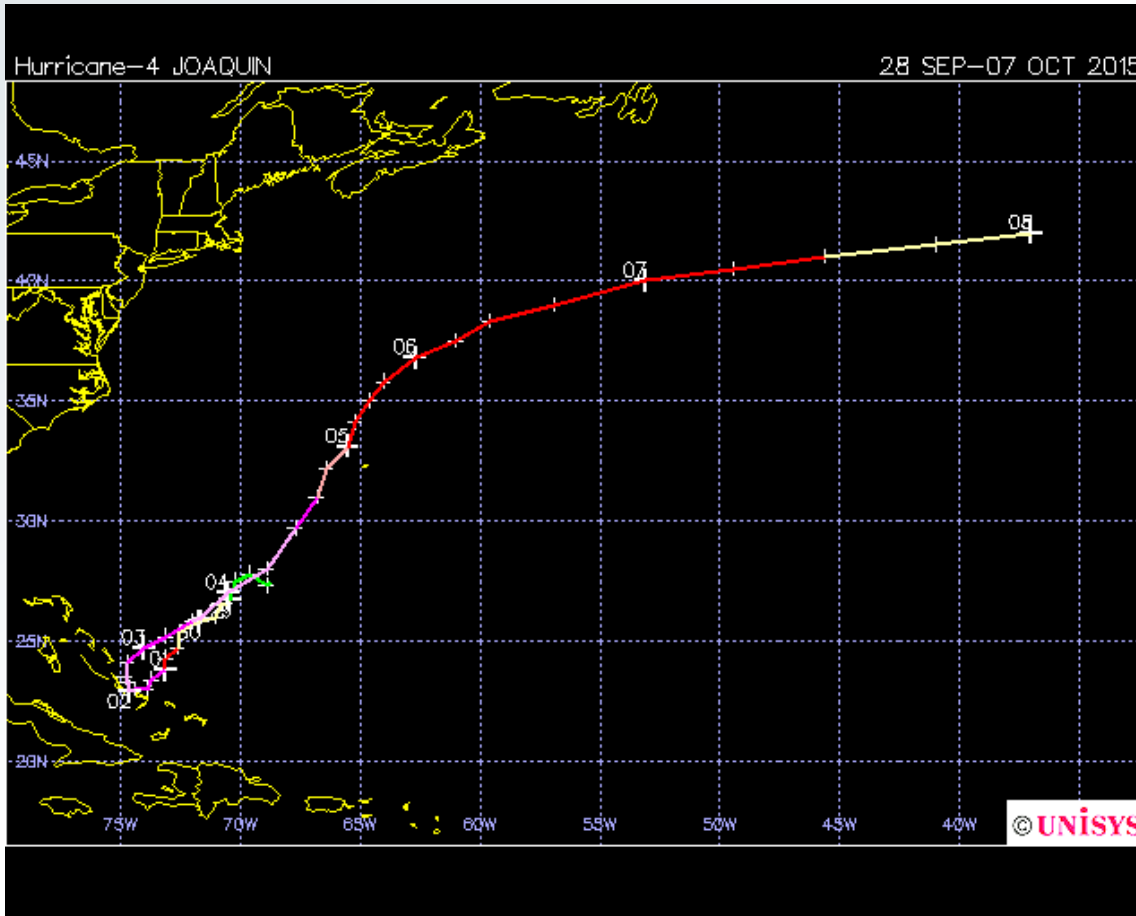


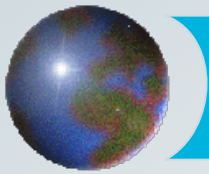
Hurr-4 JOAQUIN Forecast





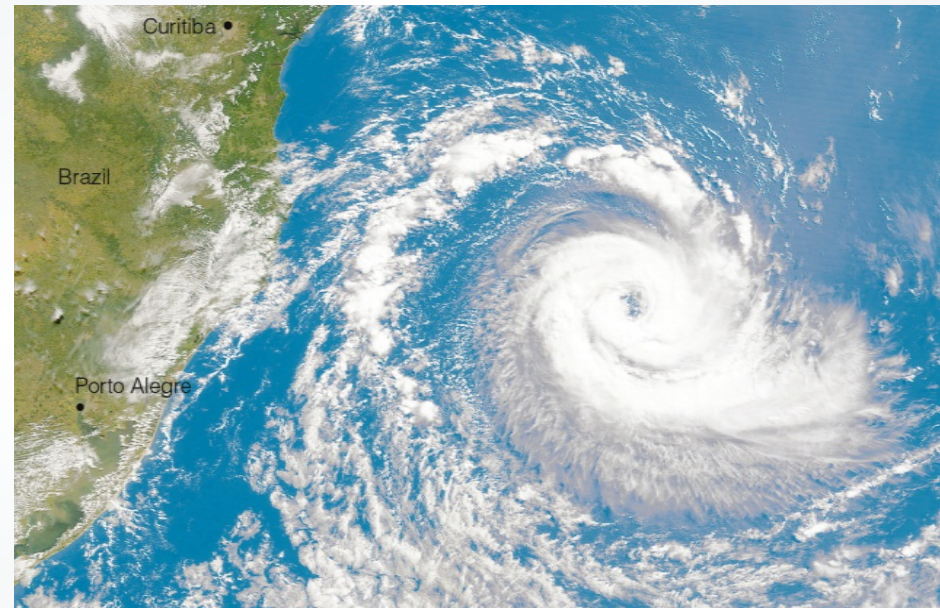
Hurr-4 JOAQUIN 28 SEP-08 OCT

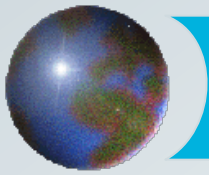




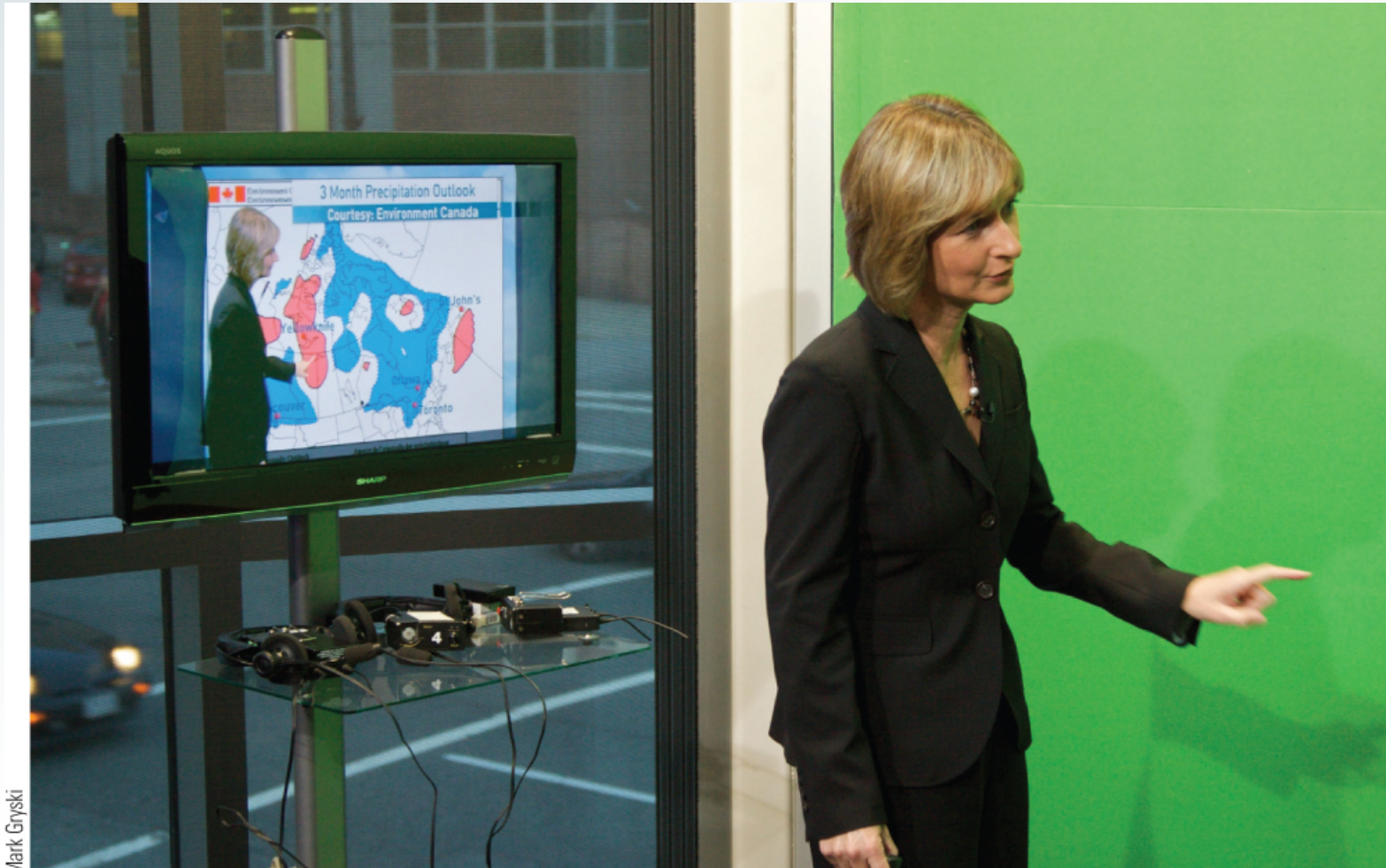
Cyclone Catarina

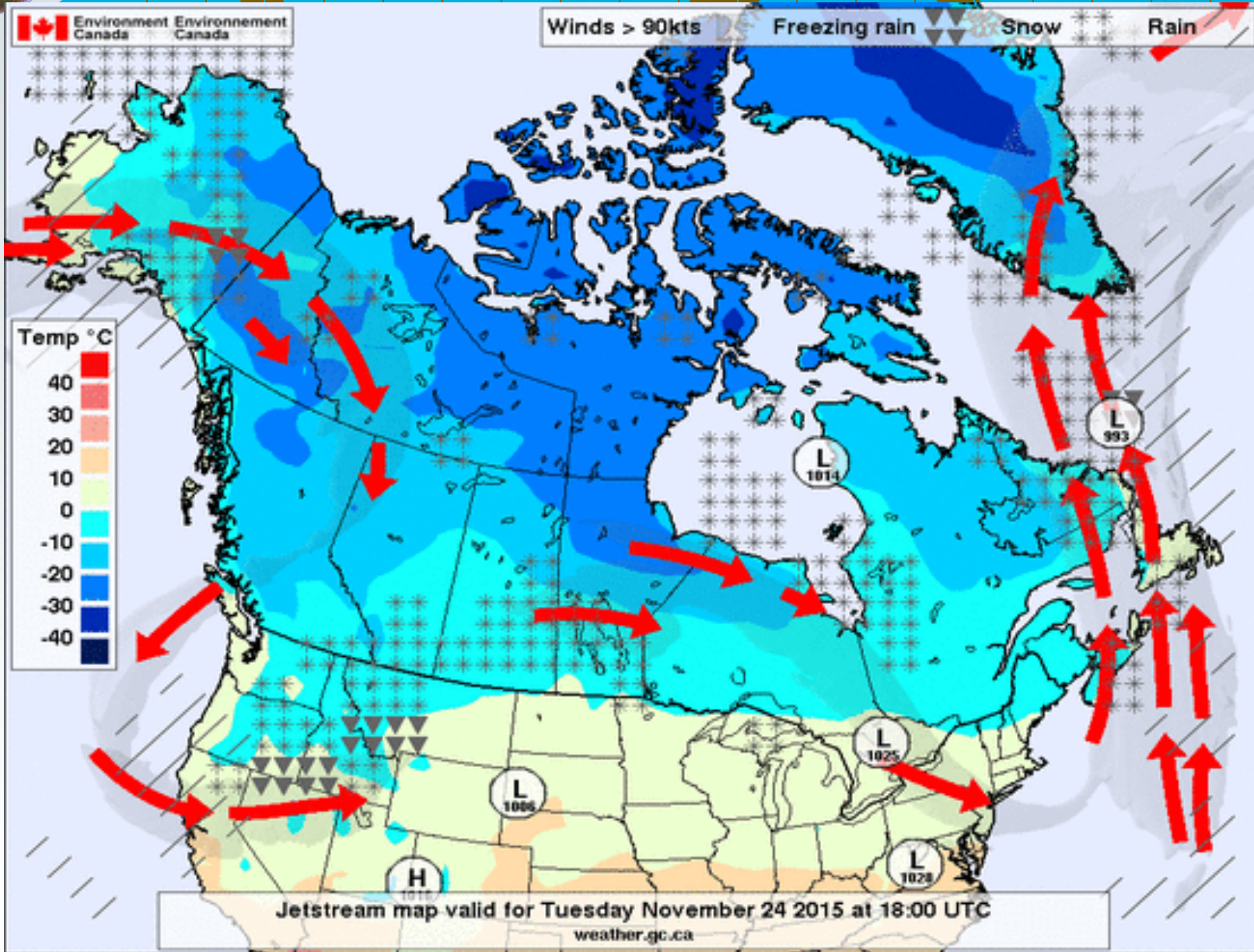
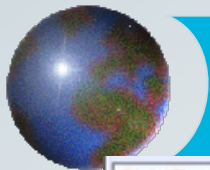
- ✦ March 26-27, 2004
- ✦ First hurricane-strength storm observed in the South Atlantic
 - ✦ Category 2, 160 km/h
- ✦ Why now?
 - ✦ Combination SSTs and atmospheric flow
- ✦ Four tropical storms over 2010-2015

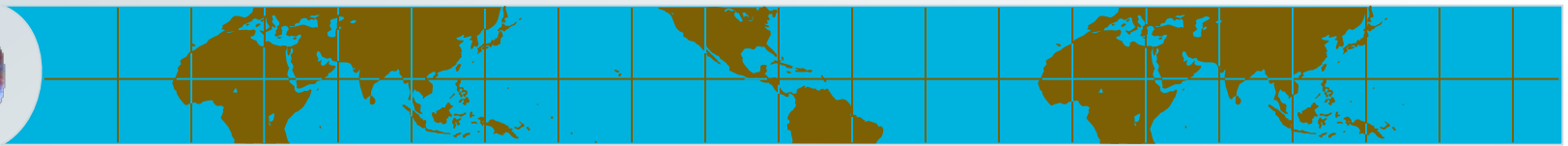
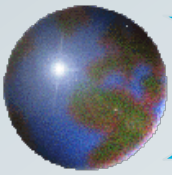




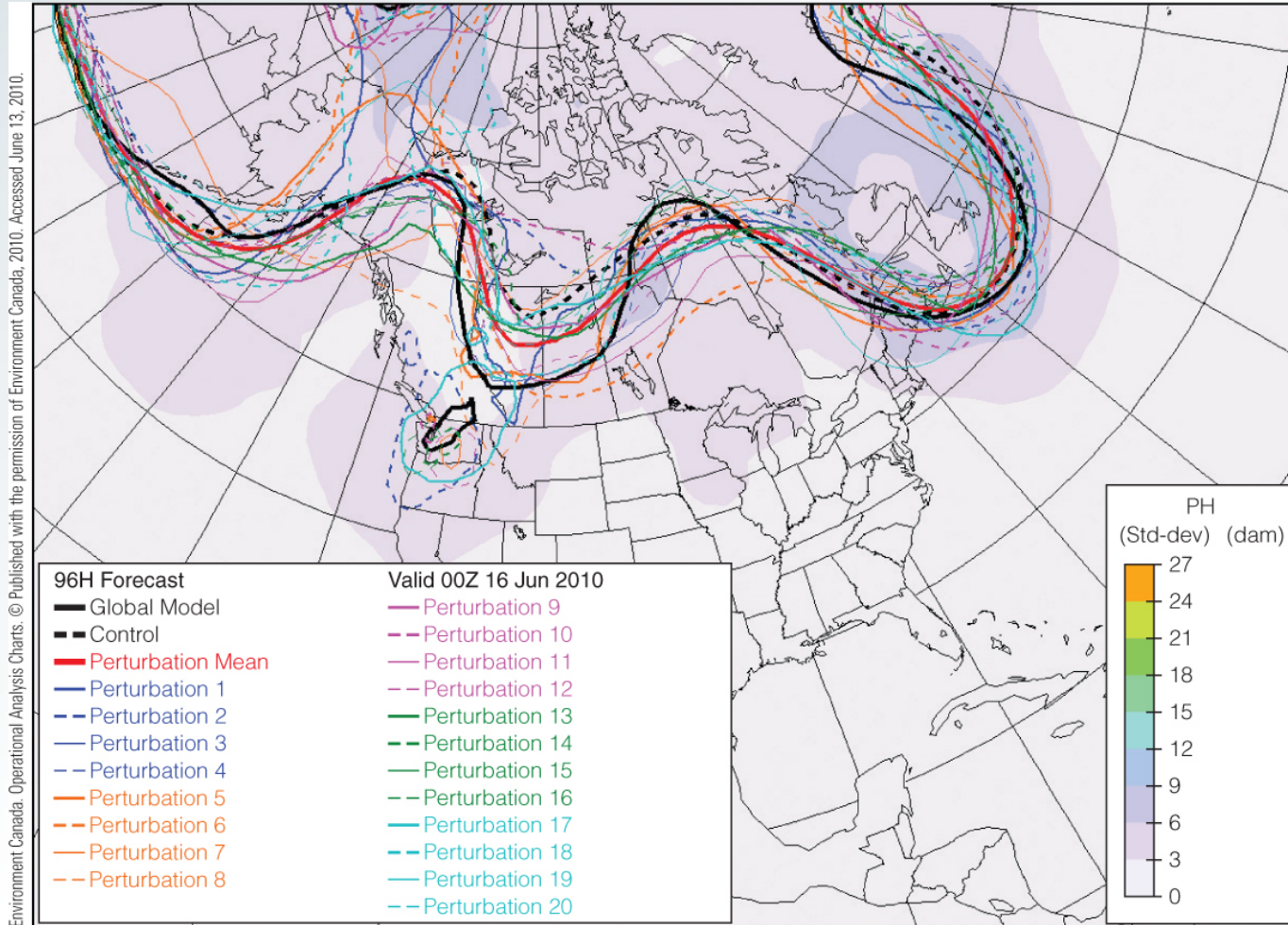
Daily/Seasonal Weather Prediction



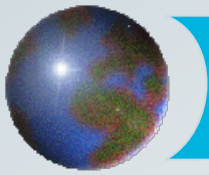




Ensemble 500-mb forecast



Ahrens: Fig. 13.7, p. 348



Next lecture

- ✦ Weather forecasting
- ✦ Polar lows
- ✦ Climate classification
 - ✦ Ahrens: Chapter 17

- ✦ Lab 7