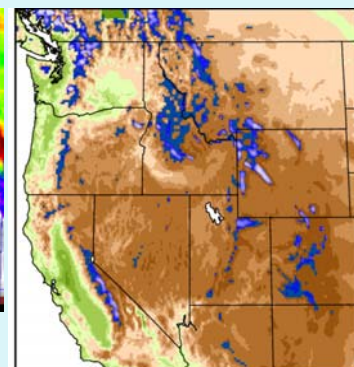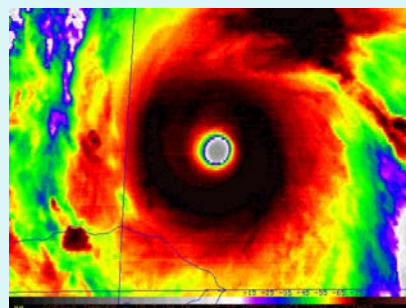# Modeling the Effects of Regional Climate Change and Variability on High Impact Weather

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Goals

- Developing a capacity for predicting regional climate at fine spatial scales over decades, using:
  - *Regional Climate Modeling*
  - *Statistical Downscaling*
  - *Development of Decision Support Tools*
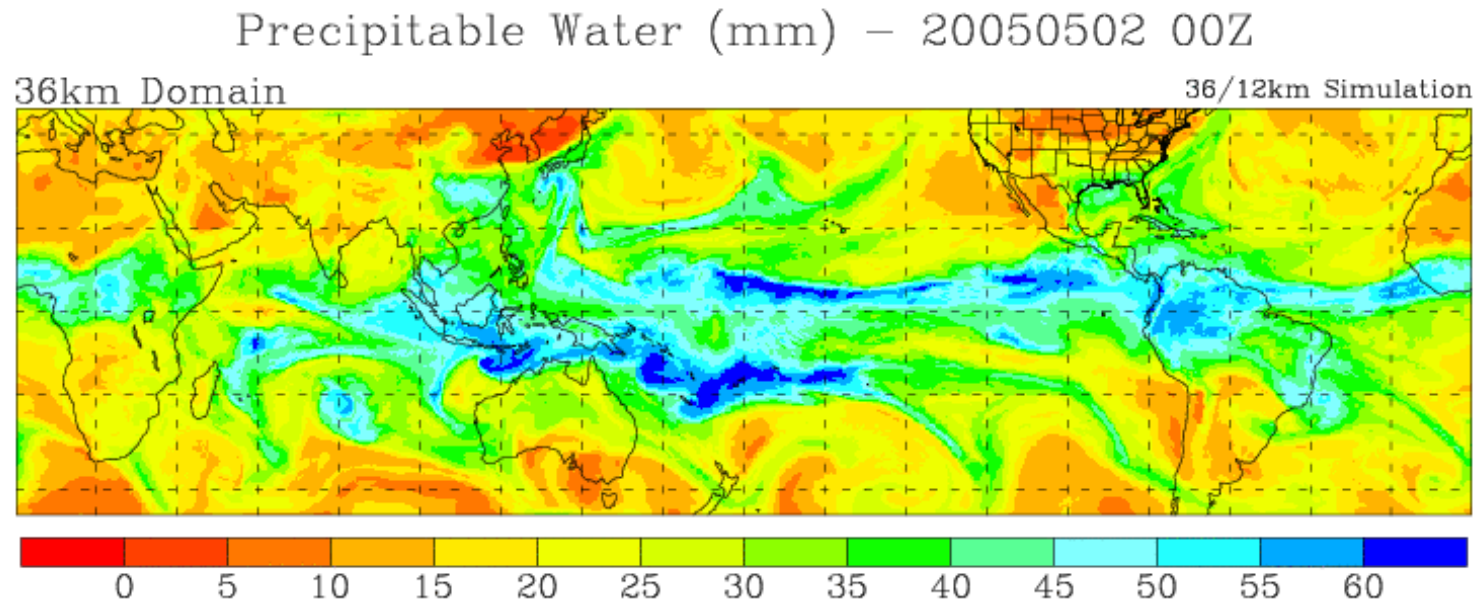
Water and Security

Energy Security

Hurricanes
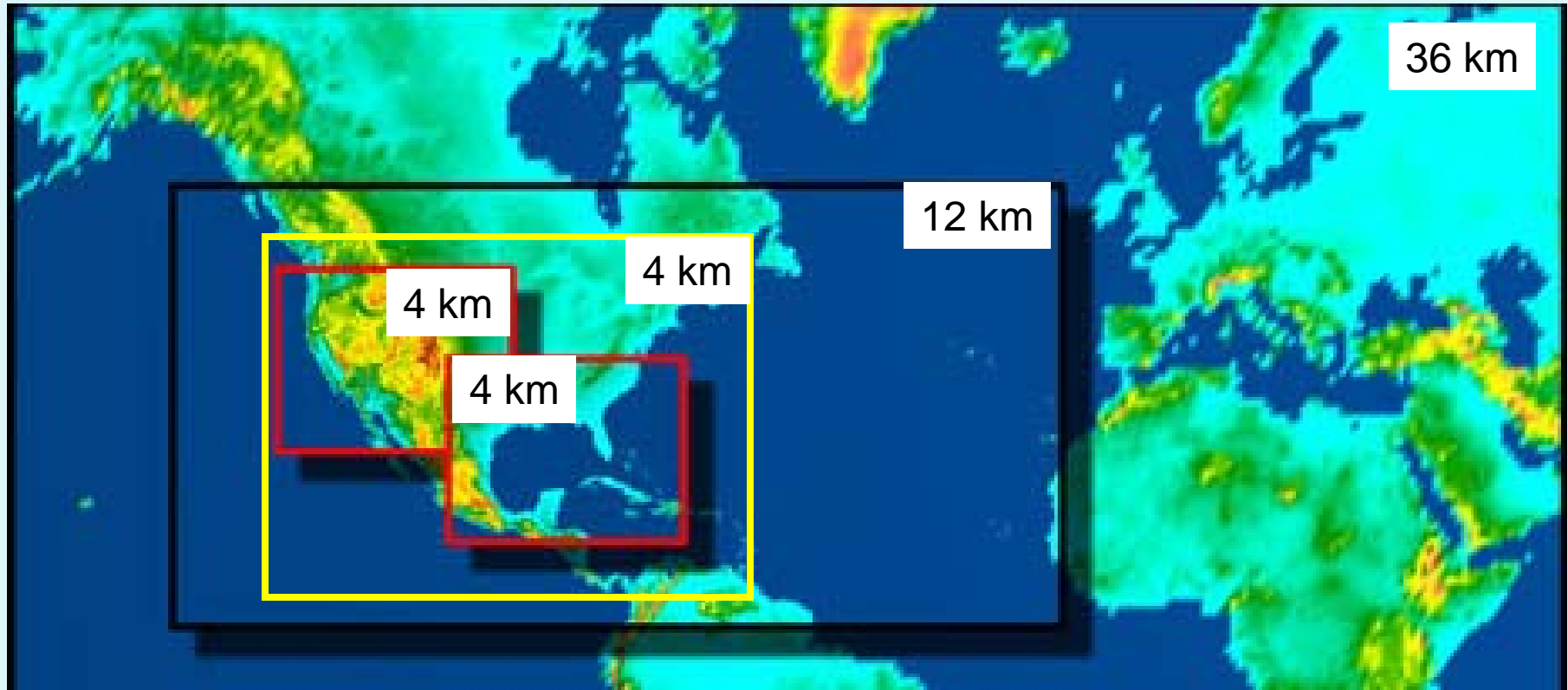
Heat Waves

NRCM Development to Date

- **Concept:** Workshop on Research Needs and Directions of Regional Climate Modeling Using WRF and CCSM (Leung, Kuo and Tribbia) March 2005;

- **NRCM V1:** Tropical Channel Model simulations of current climate;

- **NRCM V2:** North American Regional Climate.

NRCM V1: WRF Tropical Channel Model

Precipitable Water (mm) – 20050502 00Z

36km Domain
36/12km Simulation

0   5   10   15   20   25   30   35   40   45   50   55   60

NRCM V2: North American Regional Climate

Nested inside CCSM

- NRCM: 1995-2005, 2020-2030, 2045-2055 (IPCC AR1)
- Bias correction applied to CCSM Boundary Conditions
- Use of statistical downscaling
- Development of Decision Tools

NRCM V2 Projects

- CCSM Bias Correction

- Specific Foci
  - *North Atlantic Hurricanes (RPSEA, WDB, WRN)*
  - *Intermountain West Water and Snowpack (WGA)*
  - *Wind Energy (NREL)*
  - *Climate of the Mid West (ANL)*
  - *Caribbean Rainfall (CIMH)*

- Development of Tools
  - *Statistical Downscaling*
  - *Decision Support*
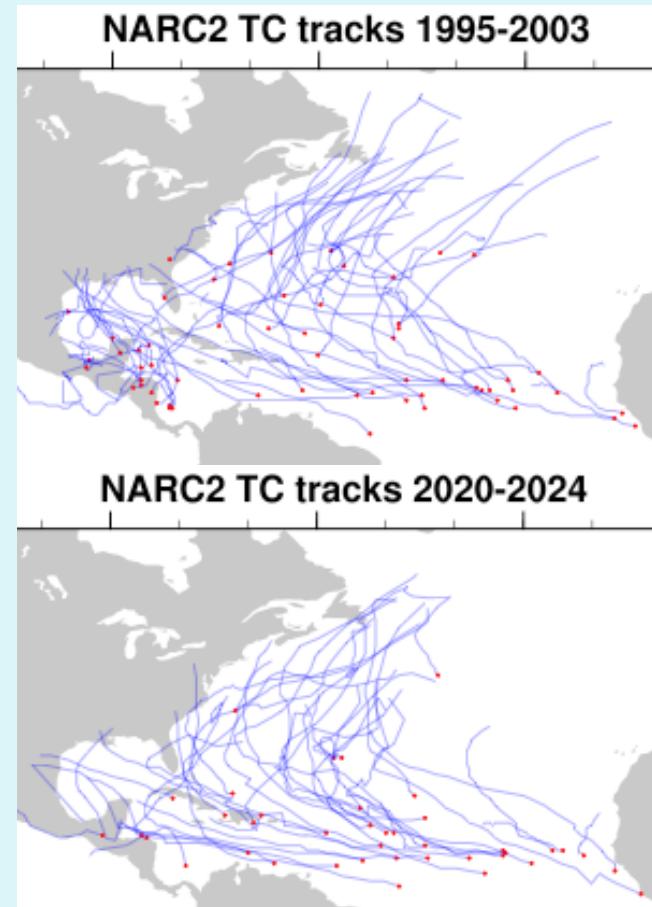
Example: North Atlantic TCs: Detection

Detection Criteria
1) Find SLP local minima
2) |Max relative vorticity| > $5\times10^{-5}s^{-1}$
3) Max wind speed > 17m/s
4) Warm core
5) Vertical thermal structure
6) Cyclone Phase
7) Must be satisfied >48 h

Sensitivity Analysis
- Cyclone Phase good at removing "subtropical" systems
- Considerable sensitivity to selection of values for criteria

(Suzuki 2010)

NARC2 TC tracks 1995-2003

NARC2 TC tracks 2020-2024

Example: North Atlantic TCs: Frequency

	Current observation	Model 1995-2030	Model 2020-2030	Model 2045-2055
Mean	7.8	7.6	8.5	10.4
STD	3.6	4.1	1.2	4.1

* Current observation: filtered to contain TC's with maximum wind > 17m/s for at least 2 days to be consistent with TC tracking criteria in model

(9-y Running mean)

(Bruyere 2010)
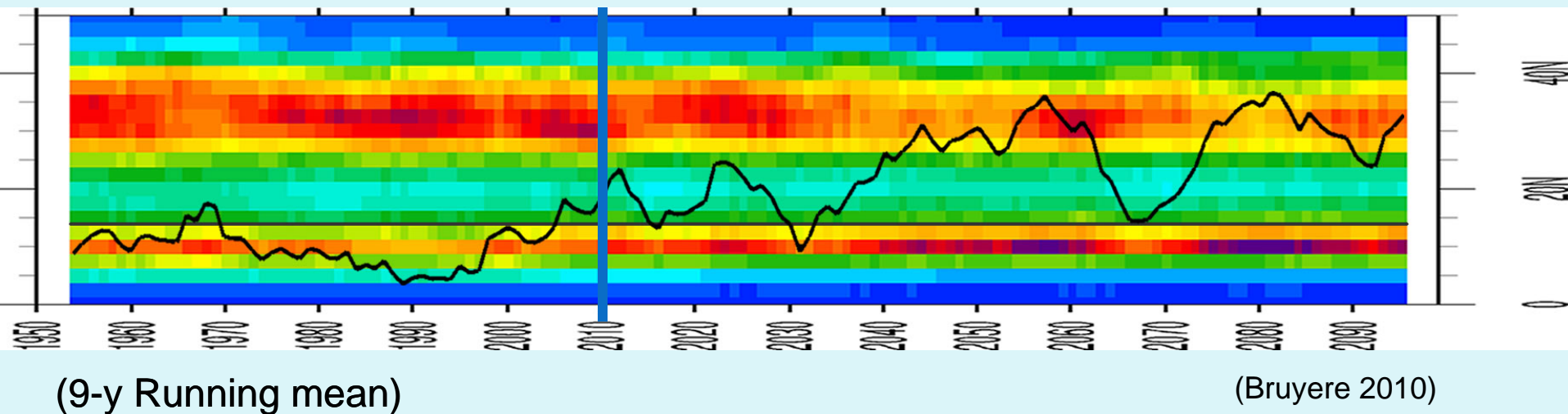
Example: North Atlantic TCs Intensity

Wind speed distribution
36 km Resolution
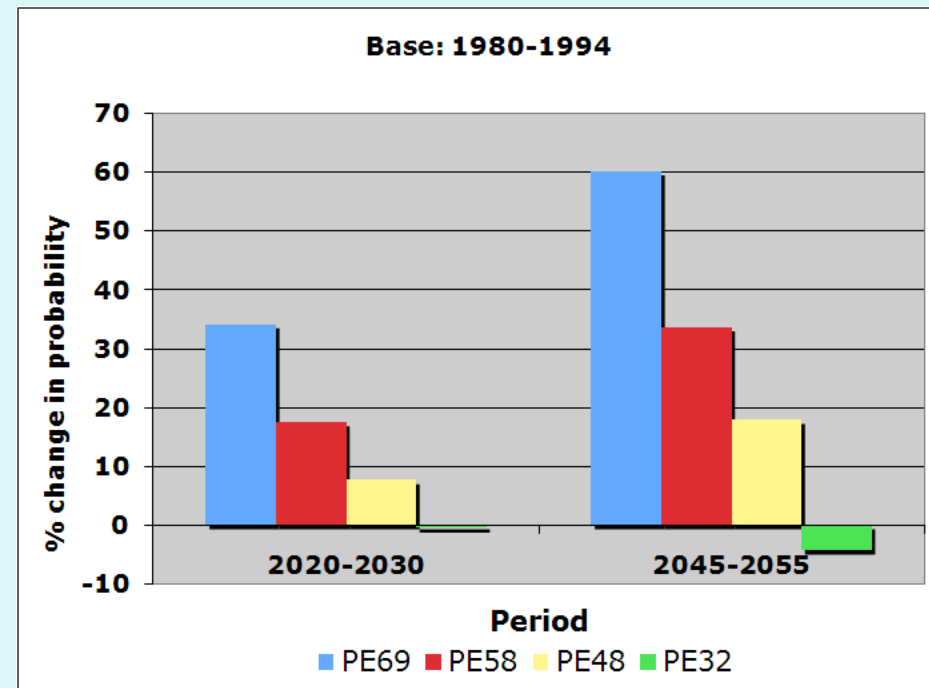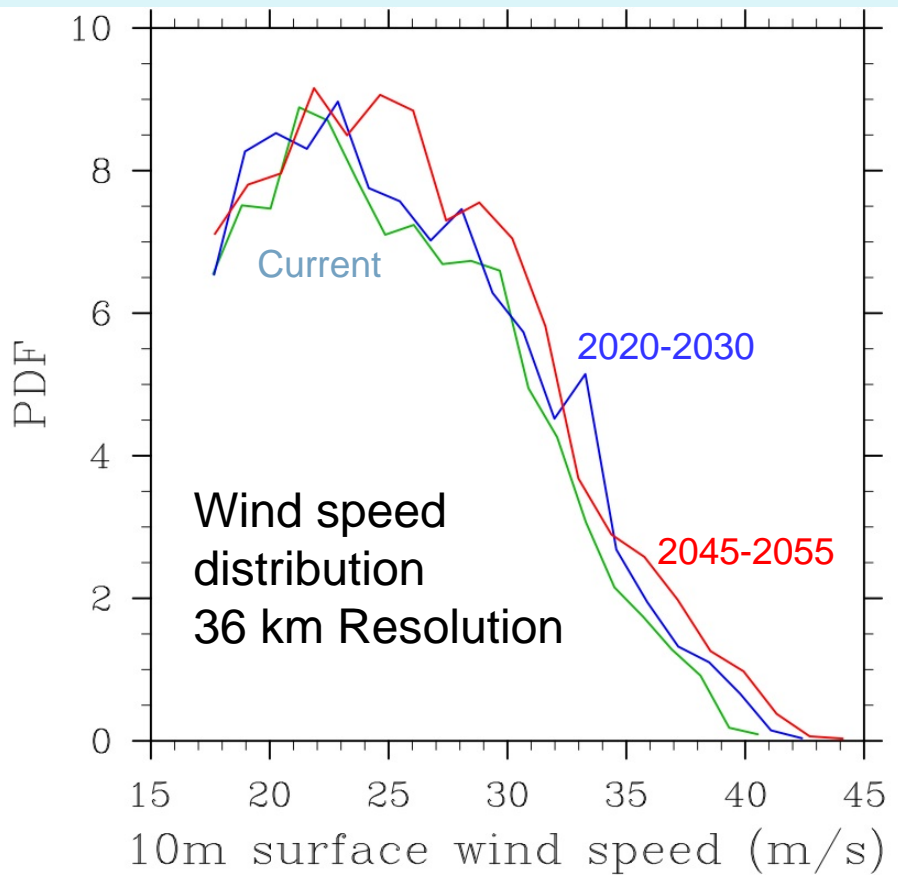
PE69=Cat5
PE58-Cat4,5
PE48=Major Hurricanes
PE32=Hurricanes

(Holland 2010)

Example: Decision Tools, the Willis Hurricane Index

$$WHI = (\frac{v_m}{65})^3 + 5(\frac{R_h}{50}) + 5(\frac{v_t}{15})^{-2}$$

$$For\ v_t < 25\ and\ v_m > 65,$$

$$If\ v_t < 7, v_t = 7,$$ (Holland and Owens (2009))

Parameter	1995-2005	2020-2030	2045-2055
# Cyclones	15	10	20
Average Intensity (ms^{-1}/kt) Maximum Intensity (ms^{-1}/kt)	26/50 37/72	25/49 34/67	25/49 37/73
Average Rmax (km/nm)	81/44	45/24	58/31
Average Trans. Speed (ms^{-1}/kt	5/10	6/12	6/11
Average Hurricane WHI	24.4	19.3	22.1
Ave Hurricane Damage	$5.7b	$2.5b	$4.3b

NRCM Work in Progress

- Development:
  - *NRCM-Chem, led by Jean-Francois Lamarque and Mary Barth;*
  - *Fully coupled NRCM-CCSM (adding ROM);*

- Developing Projects:
  - *Climate of the Mid-west (with ANL);*
  - *Antarctic Climate (with NCAS);*
  - *Intermountain West Precipitation (Western Water Authorities);*
  - *New paradigm for Catastrophe Modeling (Willis Research Network, Wharton Institute, UP);*
  - *Characterizing and Quantifying Uncertainties in Climate Model Projections at the Regional Scale (ANL);*

- Major Priority
  - *Upscale Impact of Mesoscale Weather on Climate.*

The Next Generation

NRCM is helping establish an experience and regional-climate-modeling base for the new Model for Prediction Across Scales
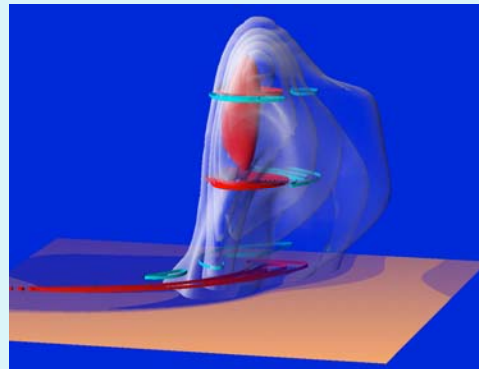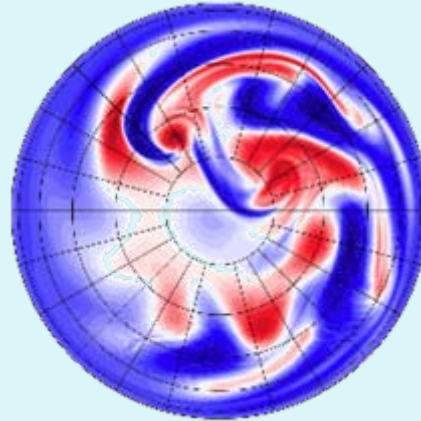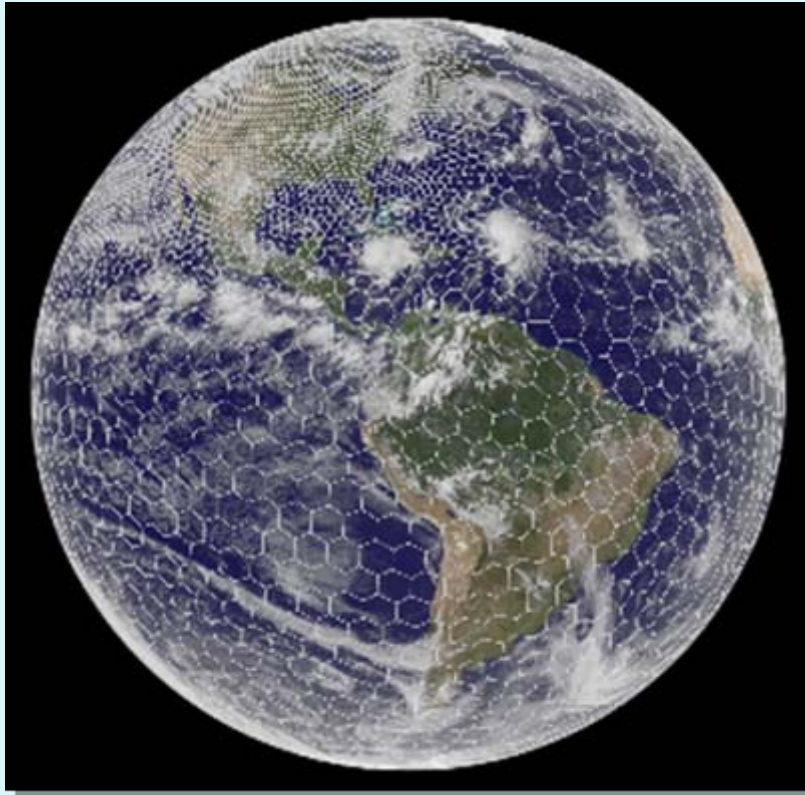
Enabling global mesoscale modeling with capacity to run on future, massively-parallel machines

Thank You

Regional Climate Prediction: Developing Leading Edge Science to Advise Society on:

Water and Security

Energy Security

Water and Tourism

Water and Energy

Severe Storms

Floods

Heat Waves

Hurricanes