Numerical Modeling of a Heavy Rainfall Event in Present and Future Climates

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Background – Extreme Value Statistical Analysis of Rainfall

Schnapp's (2014) EVA of Kennedy Space Center (KSC)

• Collected and QCed NASA TRMM rain gauge data from 1998−2012
• Moved it onto an evenly spaced grid for objective analysis using GEMPAK
• Used NCAR's Extremes Toolkit (Gilleland 2005) to create rainfall estimates for 1–100 yr return periods (30-yr example shown below)

Criteria for Selecting Representative Event for Detailed Study

1. Event had to produce extreme rainfall on multiple days
2. Event should not be totally related to a tropical cyclone
3. Event should have documented damage in Brevard County
4. Event total rainfall comparison between Titusville and each of 36 grid points in KSC analysis domain should have enough points meet Schnapp's minimum threshold for an extreme event (25 mm day^{-1})

8-10 October 2011 ("Columbus Day Weekend Storm") met these criteria.

• "Hybrid storm" studied by Beven (2012) and Volkmer et al. (2012) that caused coastal damage and was difficult to predict and warn for

Rainfall comparison graph between 30-yr event and 8-10 Oct 2011 case

• 72-h rainfall for 30-yr event
• 72-h rainfall for 8-10 Oct 2011
| 95% confidence interval for 30-yr event
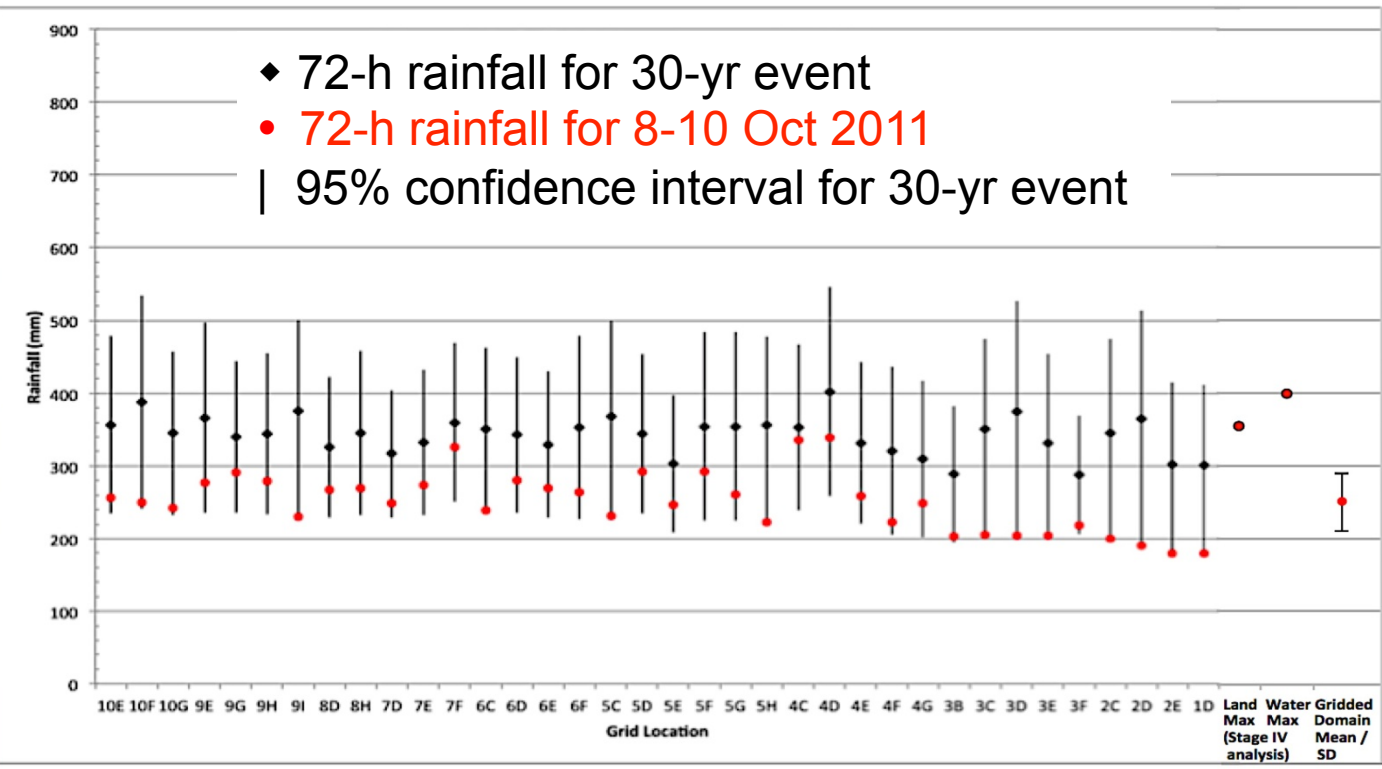
KSC analysis domain grid point locations shown in rainfall comparison graph (blue "droplets")
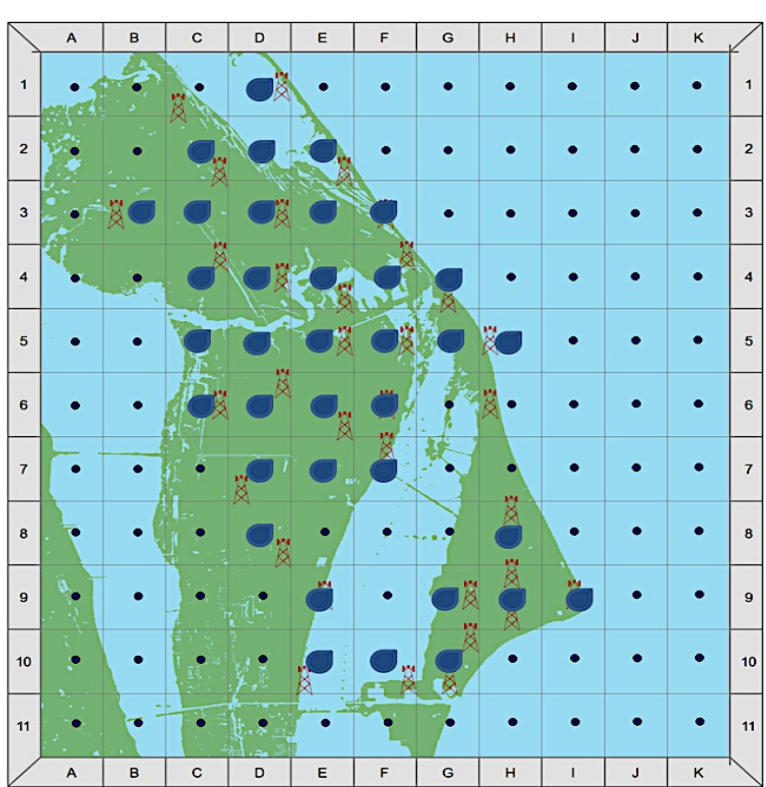
Synoptic Overview of Columbus Day Weekend Case

• Surface anticyclone from Ohio River Valley to Northeast induced strong pressure gradient and persistent easterly flow over Florida
• Inverted surface trough approached from Bahamas on the 9th, became organized low on the 10th while interacting with upper-level trough approaching from western Gulf of Mexico
• National Hurricane Center (NHC) gave system a 30% chance of developing into a tropical or subtropical system in afternoon advisory on 8th, with potential for heavy rainfall and strong winds over Florida during next 48 h
• NHC and Melbourne NWS Forecast Office focused on the system, with NHC calling it a "non-tropical gale" in late evening discussion on 9th

Surface analyses/IR satellite overlay at 1200 UTC
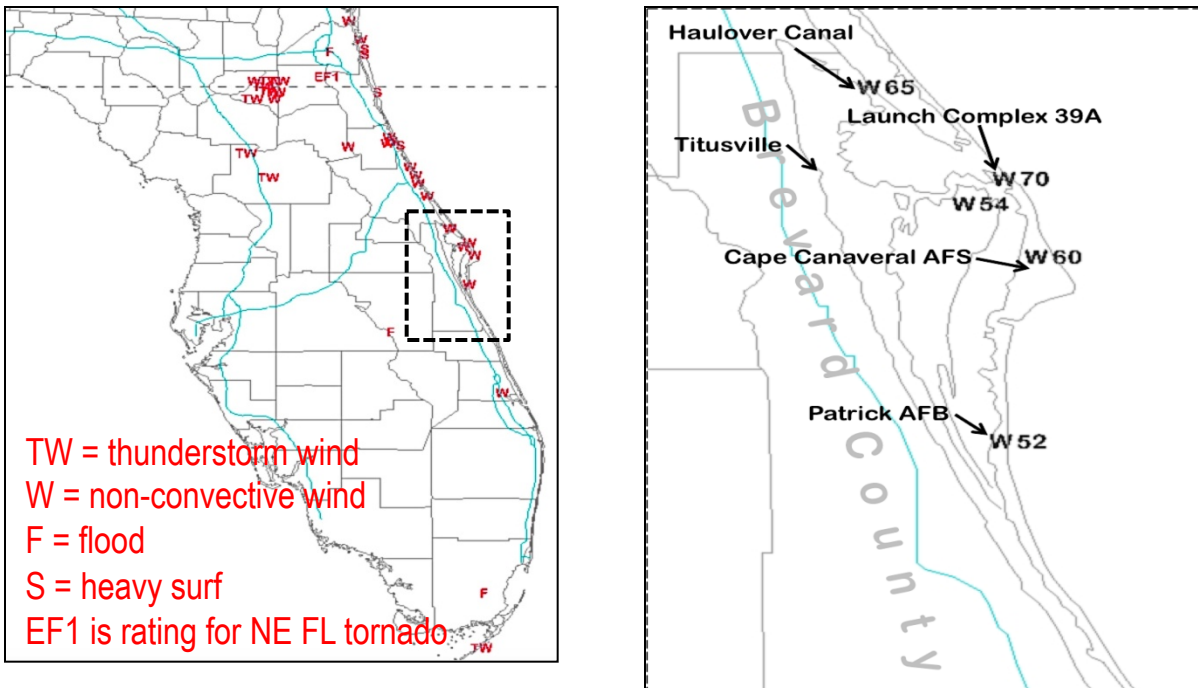(Courtesy of NWS Weather Prediction Center)
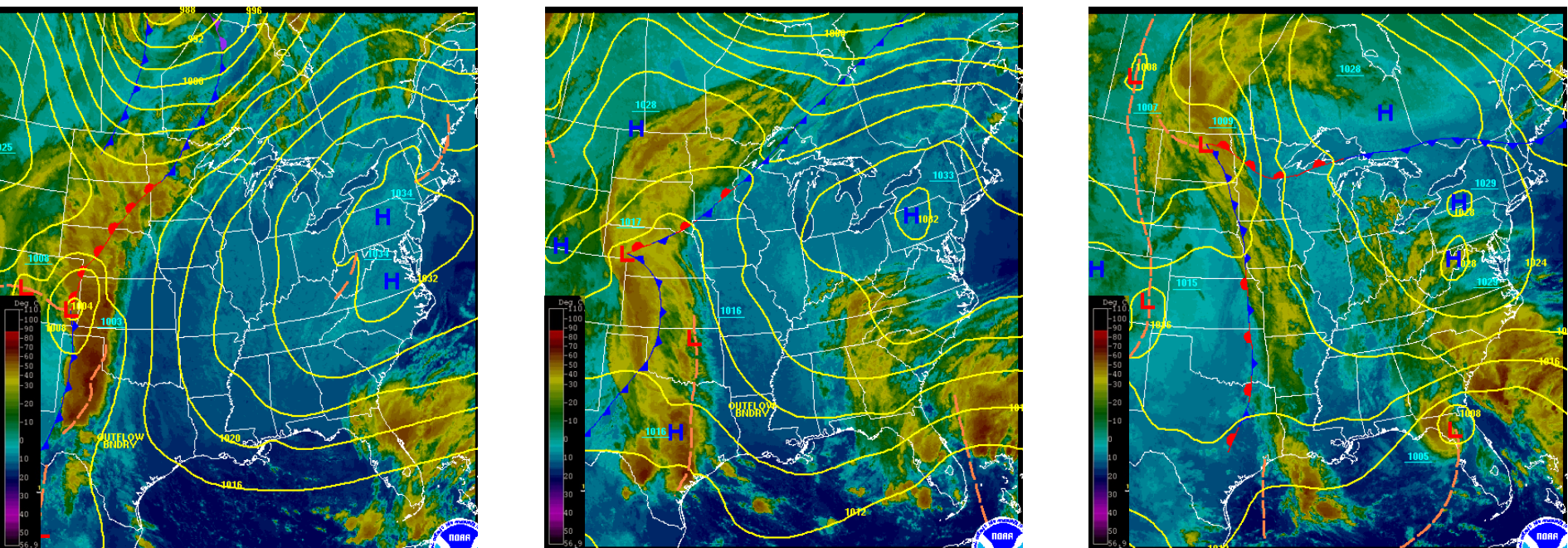
8 October   9 October   10 October

Storm damage reports over Florida (below left) and Brevard County (below right)

TW = thunderstorm wind
W = non-convective wind
F = flood
S = heavy surf
EF1 is rating for NE FL tornado

WRF Simulations of Columbus Day Weekend Storm (present climate)

Standard Configuration
(same for all nine model runs)

| Number of vertical levels: 75 |
| Ocean treatment: 1-D ocean physics |
| Planetary Boundary Layer scheme: YSU |
| Initial conditions: NCEP FNL Reanalysis |

Triple nest:
d01: 12 km
d02: 4 km
d03: 1.33 km
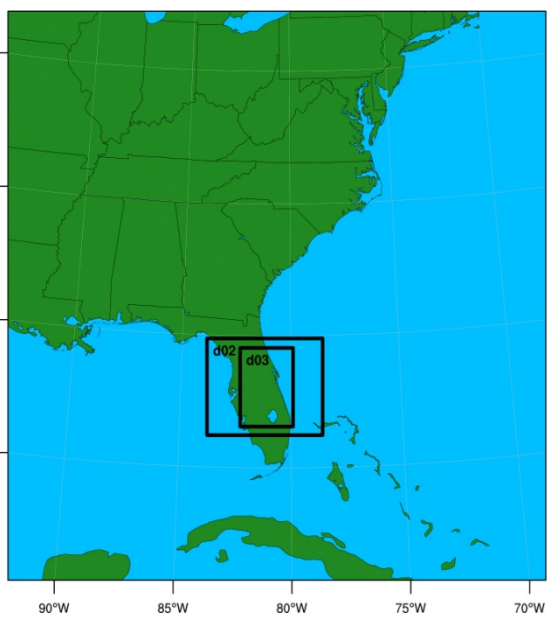
Microphysics (MP) & Cumulus Parameterizations (MP) and nesting (varied in all nine model runs)

Run	Initialization Time	MP	CP	Nesting
1	0000 UTC 7 Oct	WDM6	New SAS	One-way
2	0000 UTC 7 Oct	WDM6	New SAS	One-way
3	0000 UTC 7 Oct	WDM6	New SAS	Two-way
4	1200 UTC 7 Oct	WDM6	New SAS	Two-way
5	1200 UTC 7 Oct	WDM6	New SAS	Two-way
6	1200 UTC 7 Oct	Lin	BMJ	One-way
7	1200 UTC 7 Oct	Lin	BMJ	Two-way
8	1200 UTC 7 Oct	WSM3 (d01), WSM6 (d02, d03)	BMJ	One-way
9	1200 UTC 7 Oct	WSM3 (d01), WSM6 (d02, d03)	BMJ	Two-way

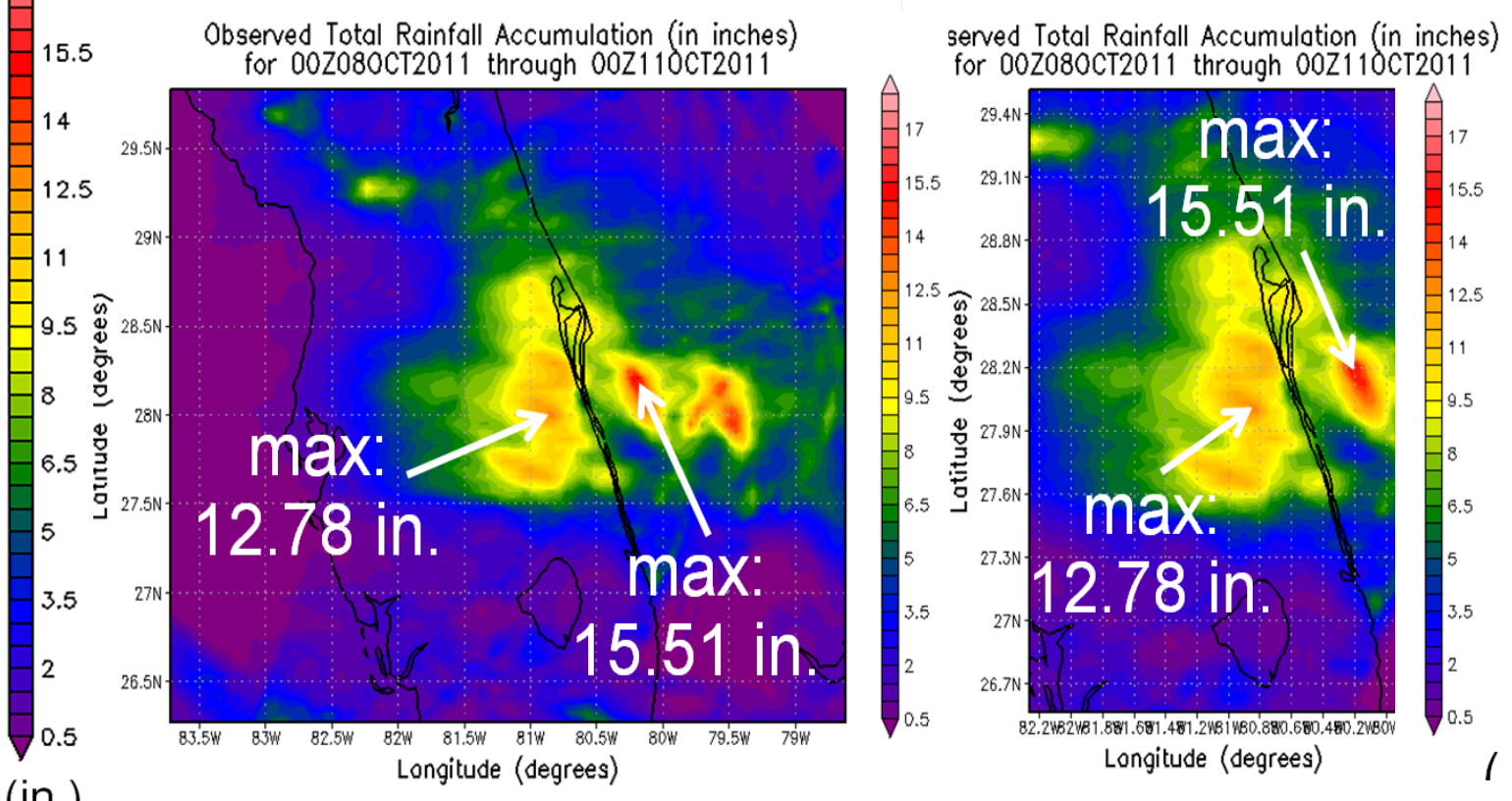## Preliminary Results

72-h precipitation forecasts from all nine model runs
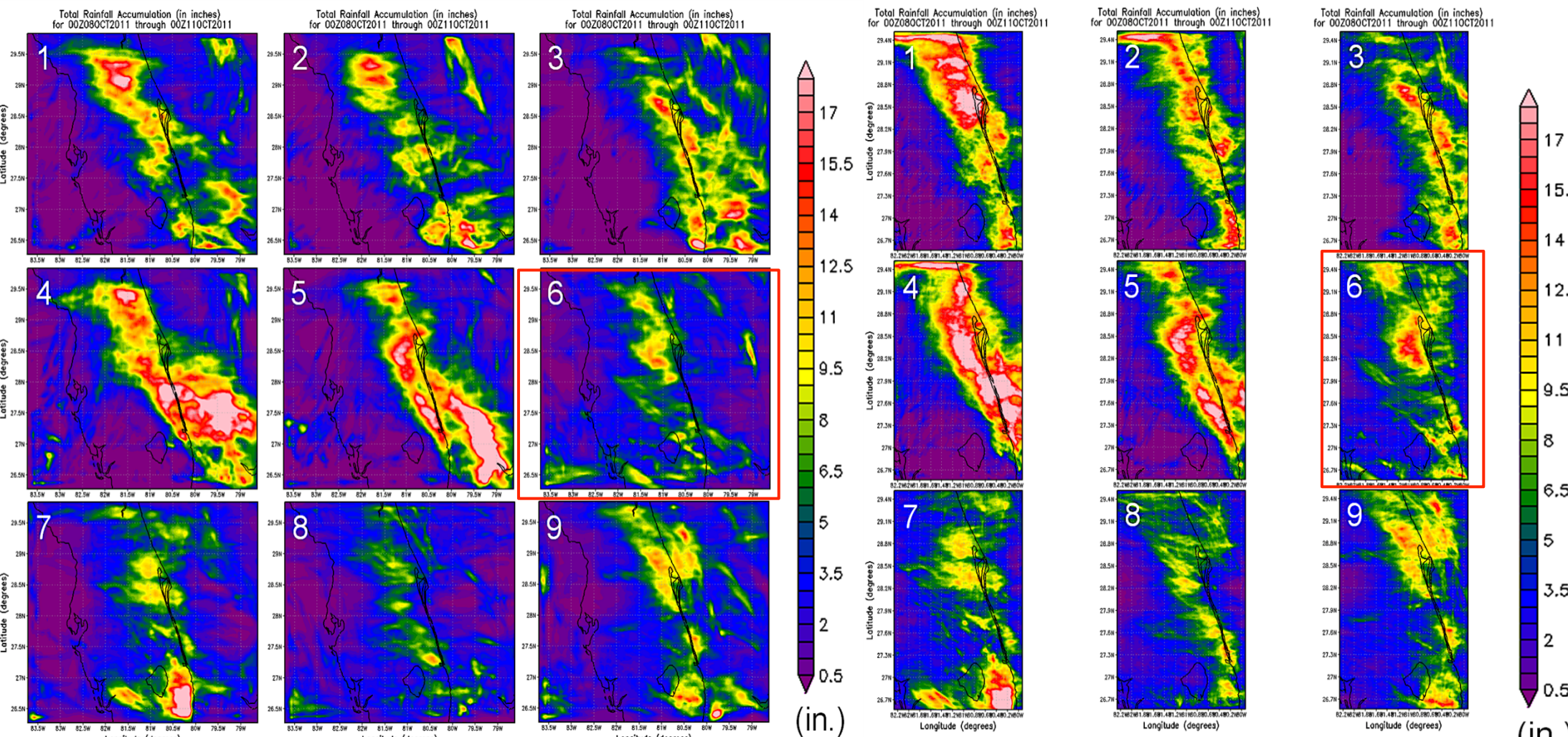
Domain d02   Domain d03

Run #6 (highlighted red in table above and in figures to left) was most accurate (See observed rainfall for d02, d03 below)

Observed Total Rainfall Accumulation (in inches) for 00Z08OCT2011 through 00Z11OCT2011

max: 12.78 in.   max: 15.51 in.

max: 15.51 in.   max: 12.78 in.

Domain d02   Domain d03

## WRF Simulations of Columbus Day Weekend Storm (future climate)

• We will use future climate projections from datasets of the fifth phase of the Coupled Model Intercomparison Project (CMIP5; Taylor et al. 2012) to generate initial and boundary conditions for WRF simulations of the 8–10 October 2011 case
• Our choice of data is known as Representative Concentration Pathways (RCPs; Wayne 2013); we will use RCP8.5 and RCP4.5 to cover an appropriate range of future climate possibilities

Increase in mean global temperature for the various RCP options [after Architecture 2030 (2014)]
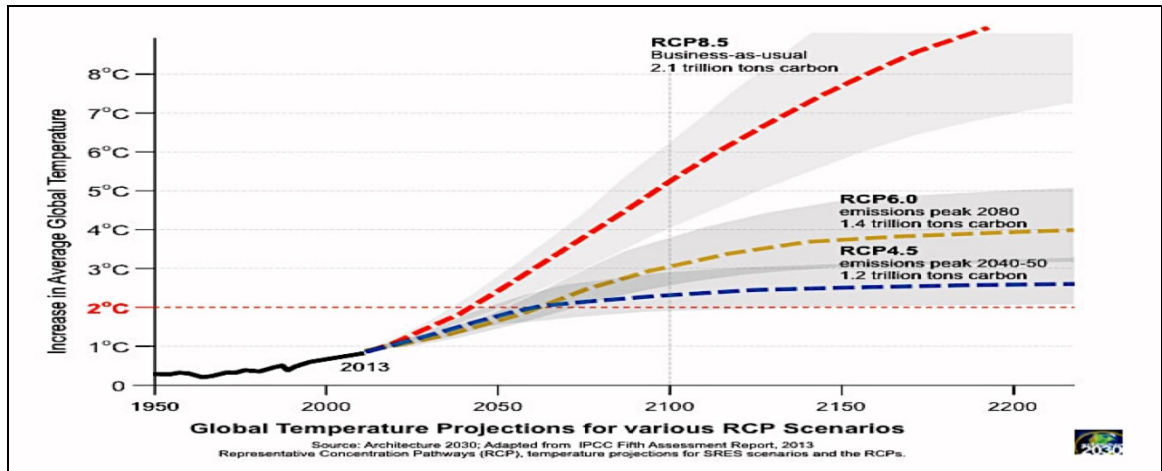
Five global climate models (GCMs) chosen for boundary/initial conditions in WRF future climate simulation

Model	Horizontal Grid Spacing (deg)
HadGEM-AO	1.25 × 1.875
HadGEM-ES	1.25 × 1.875
CNRM-CM5	1.4 × 1.4
MPI-ESM-LR	1.8 × 1.8
MRI-CGCM3	1.1 × 1.1

Pseudo Global Warming (PGW) Method
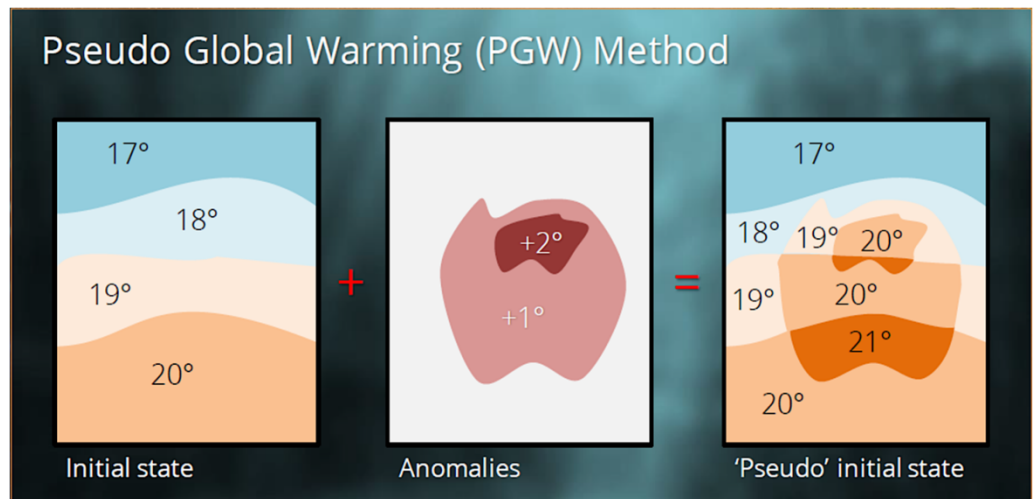
• GCM data will be placed onto a common reference grid to obtain mean surface and air temperatures from the multi-model mean
• Perturbations = 2090s – 1990s, and will then be added to WRF initial conditions using Pseudo Global Warming Approach (Nissenbaum et al. 2015)
• Rainfall from present- and future-climate WRF simulations will be compared to determine to the extent possible which physical and/or dynamical factors lead to differences in rainfall

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