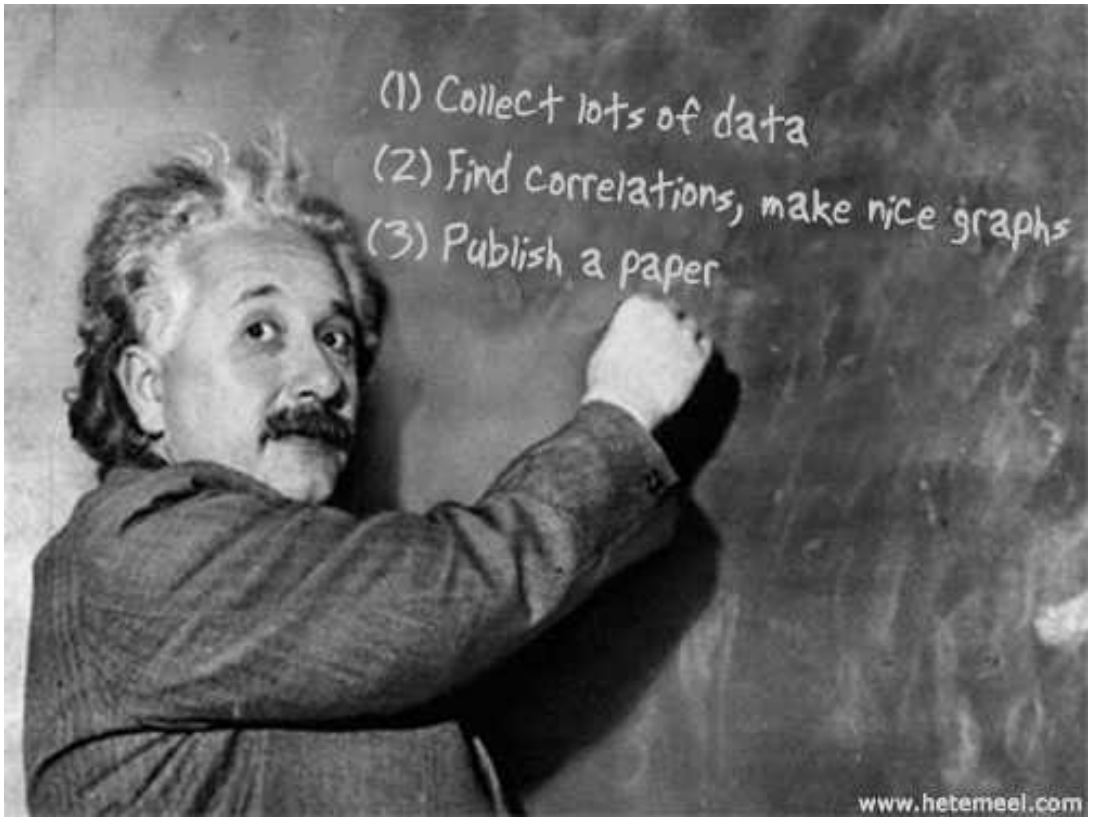
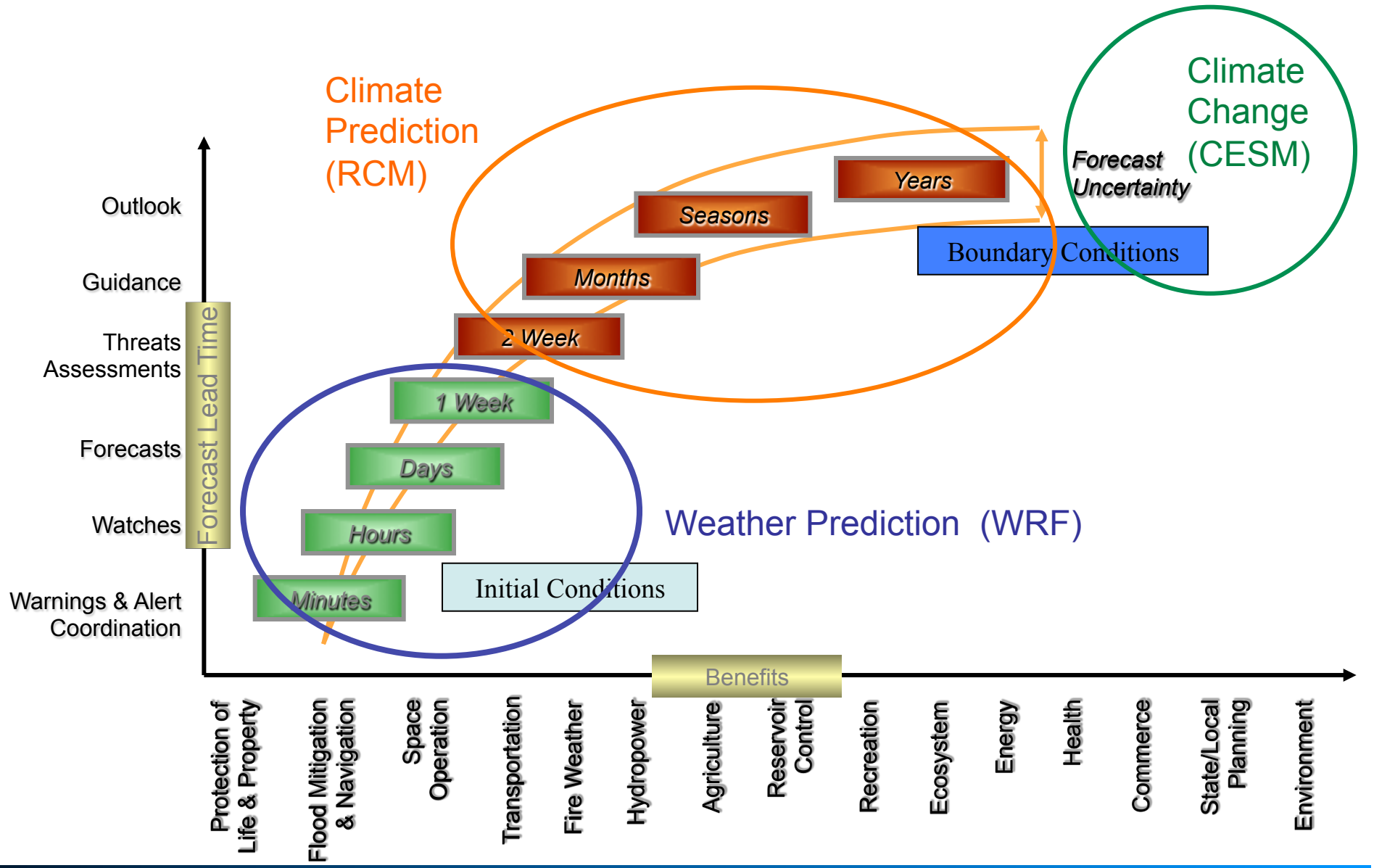
# Model Design

*Cindy Bruyère*



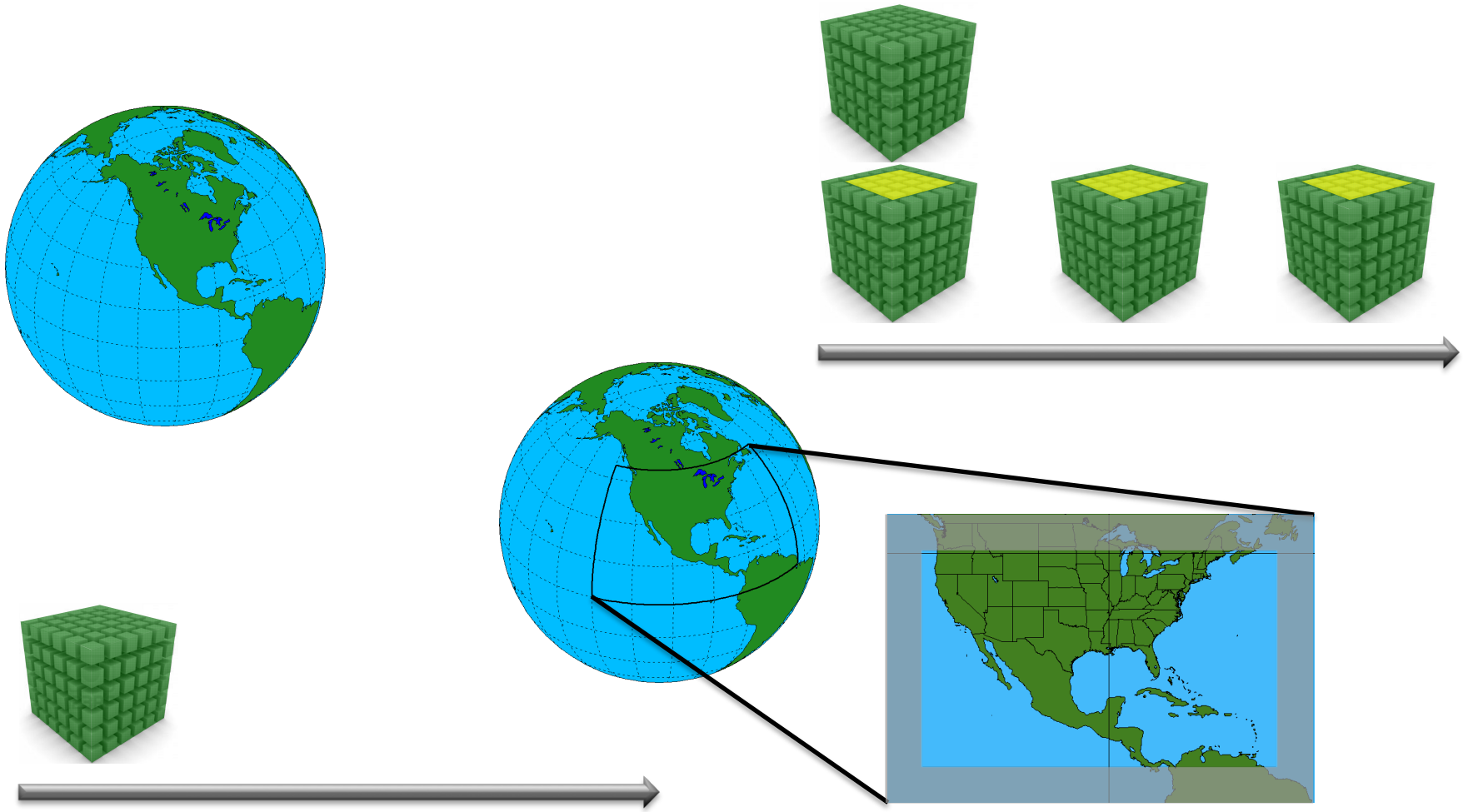
# Weather vs Climate



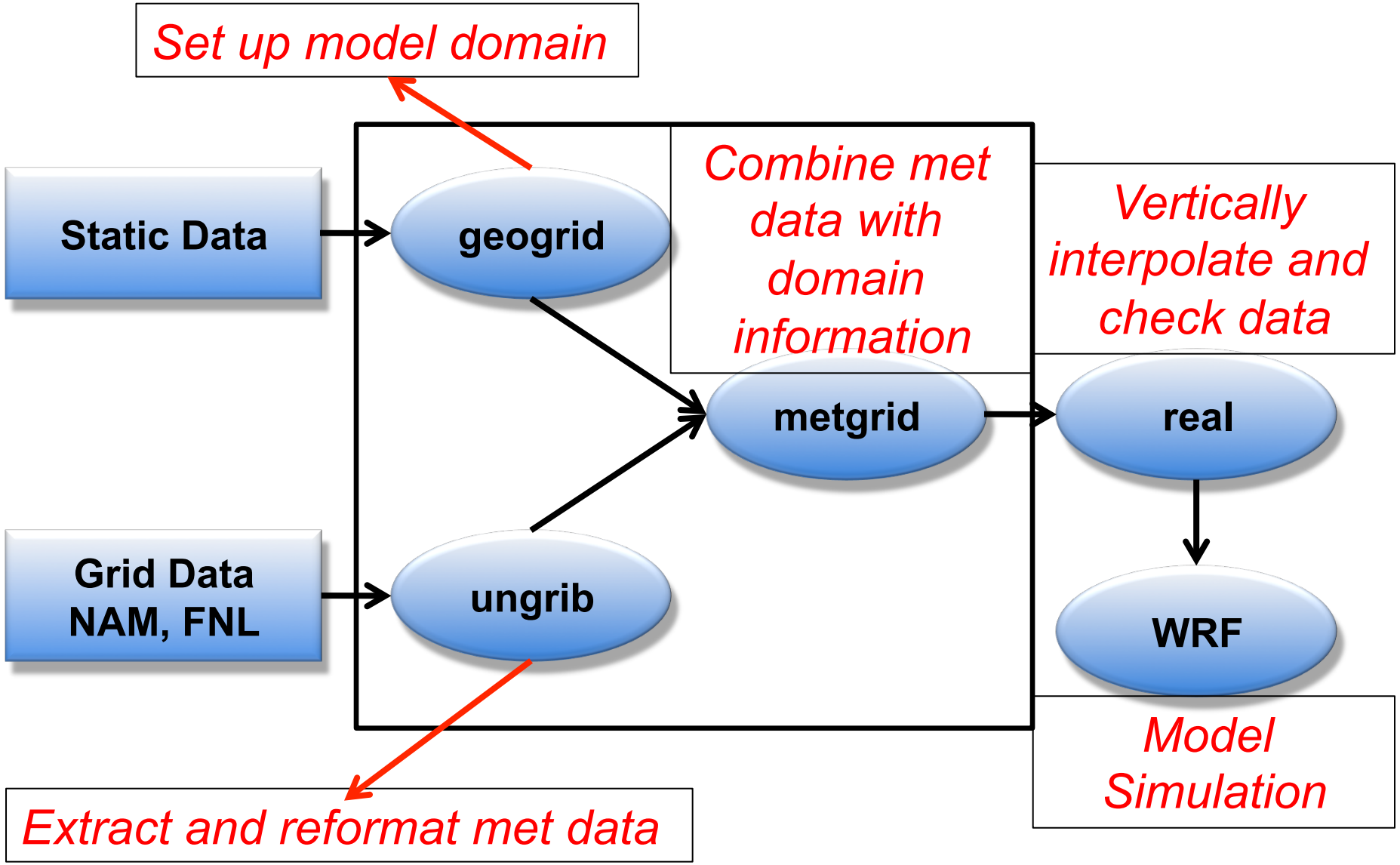
# Considerations for Model Design

- Input data
  - Format ; Bias ; SST
- Domain size
  - Area of interest
  - Inflow areas
- Model runs
  - Long runs vs time slices
- One-way vs Two-way nesting
- Choice of physics
- Surface (Coupling)
- Namelist options
- Resolution
- Nudging

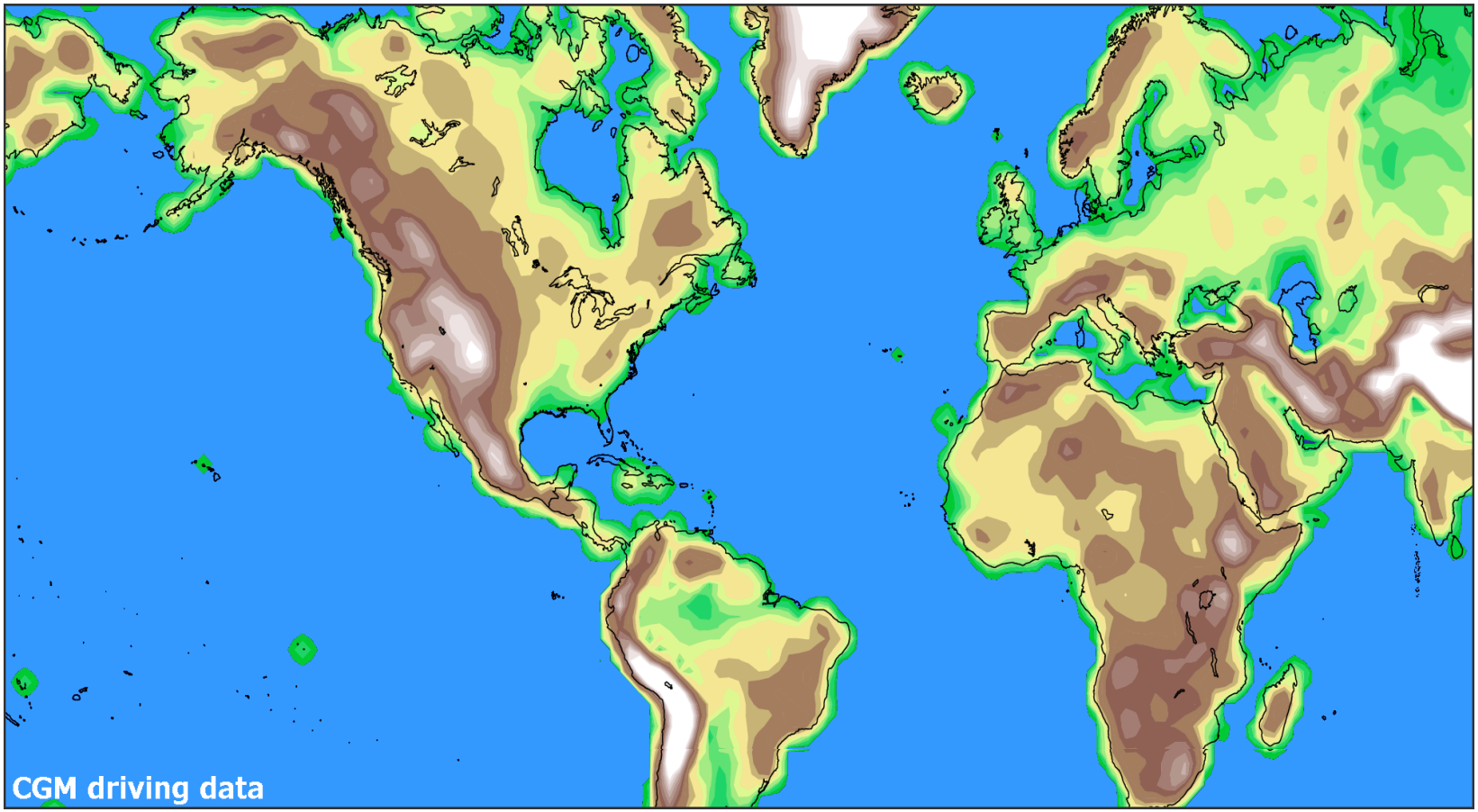
# Global vs Regional Models



# WRF System


Set up model domain
Static Data
geogrid
Combine met data with domain information
Vertically interpolate and check data
metgrid
real
Grid Data NAM, FNL
ungrib
WRF
Model Simulation
Extract and reformat met data

# Domain Size / Boundary



# Domain Size - Influence of Lateral Boundaries

## 250mb Pressure

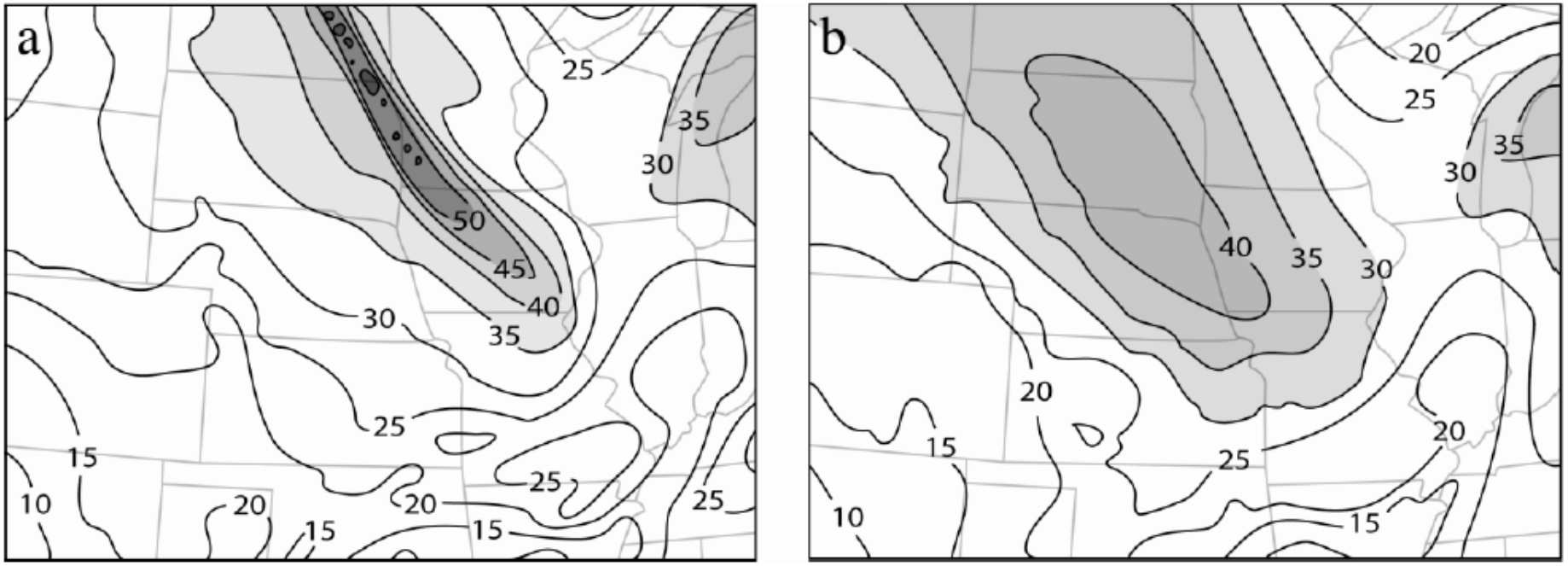
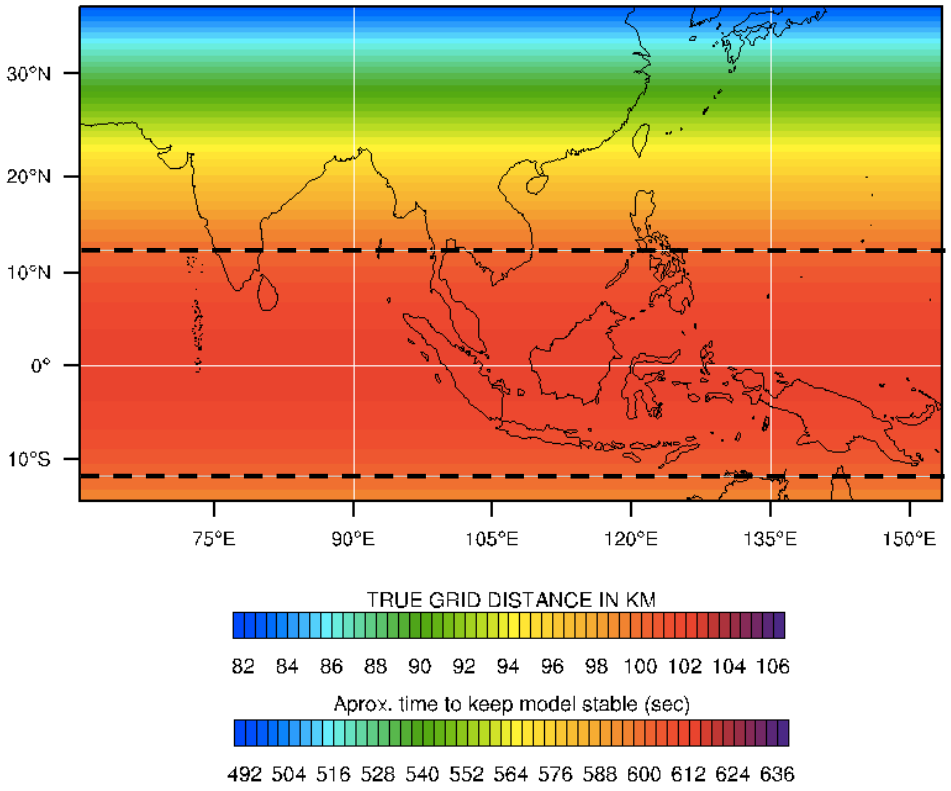



**Figure. Twelve-hour simulations of 250-hPa winds (m s-1) from the 40-km grid increment Eta Model initialized at 1200 UTC 3 August 1992, based on experiments that used a large (a) and small (b) computational domain. The isotach interval is 5 m s-1.**

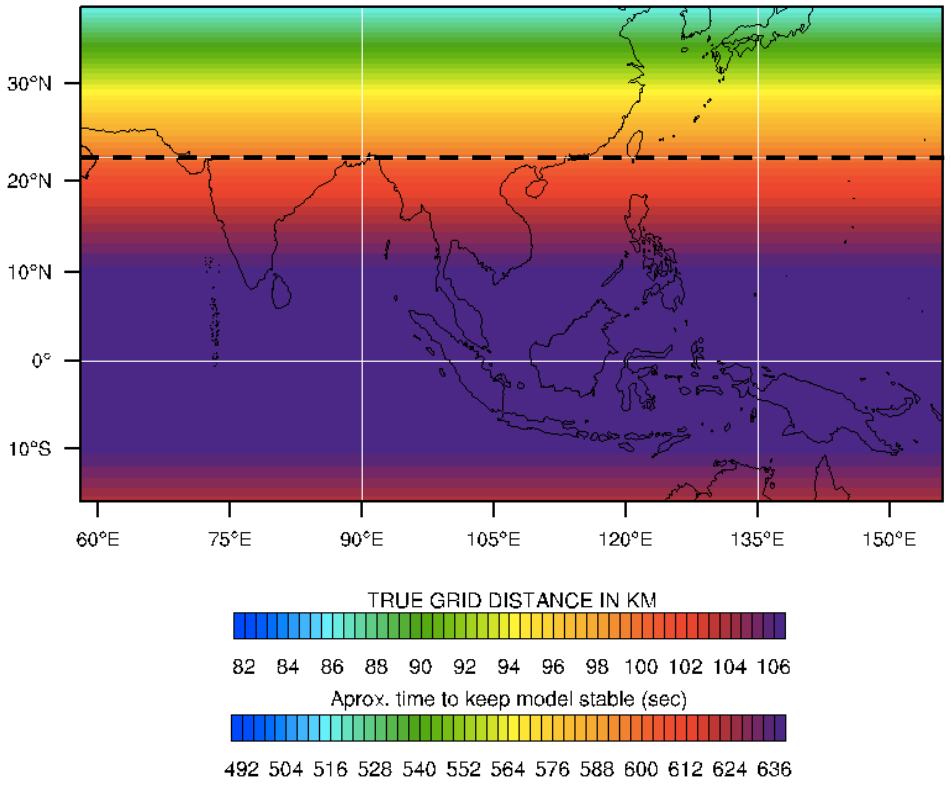
*Warner, 2011*

# Effect of TRUELAT

| | |
|---|---|
| dx | = 100000, |
| dy | = 100000, |
| map_proj | = 'mercator', |
| ref_lat | = 12.0, |
| ref_lon | = 107.0, |
| truelat1 | = 12.0, |

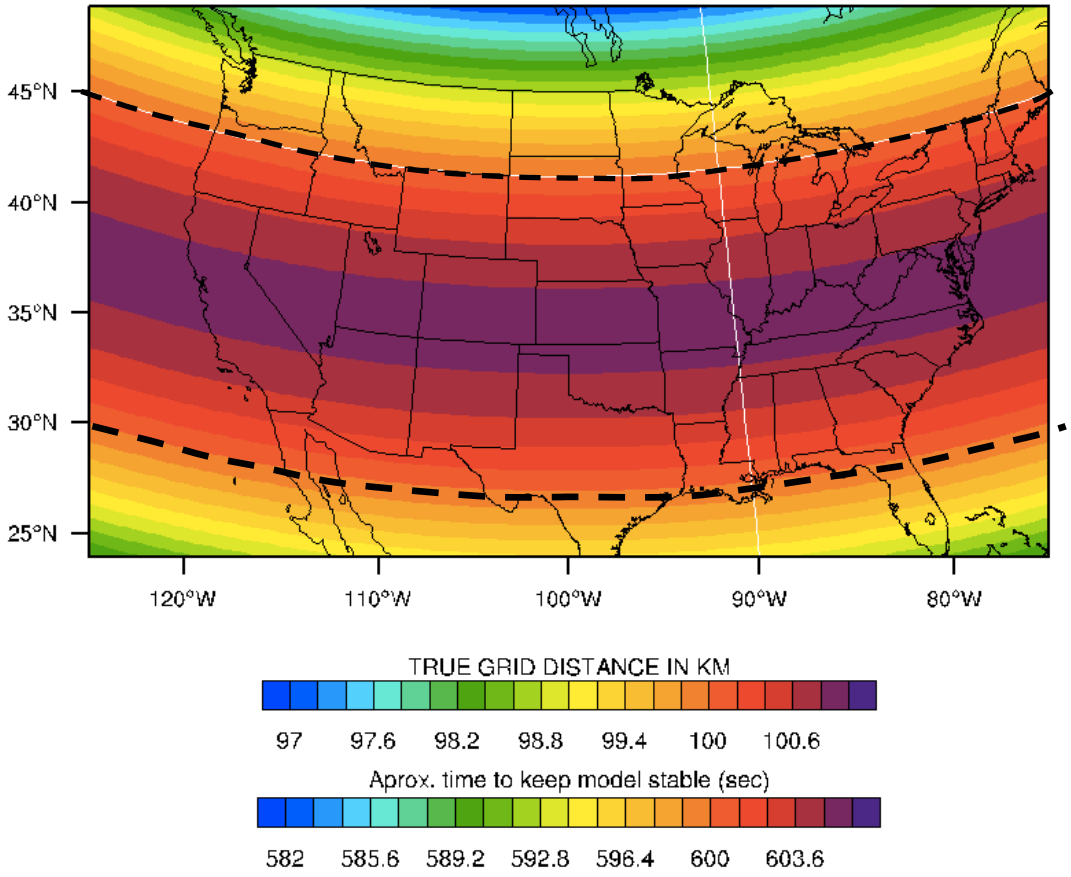



| | |
|---|---|
| dx | = 100000, |
| dy | = 100000, |
| map_proj | = 'mercator', |
| ref_lat | = 12.0, |
| ref_lon | = 107.0, |
| truelat1 | = 22.0, |

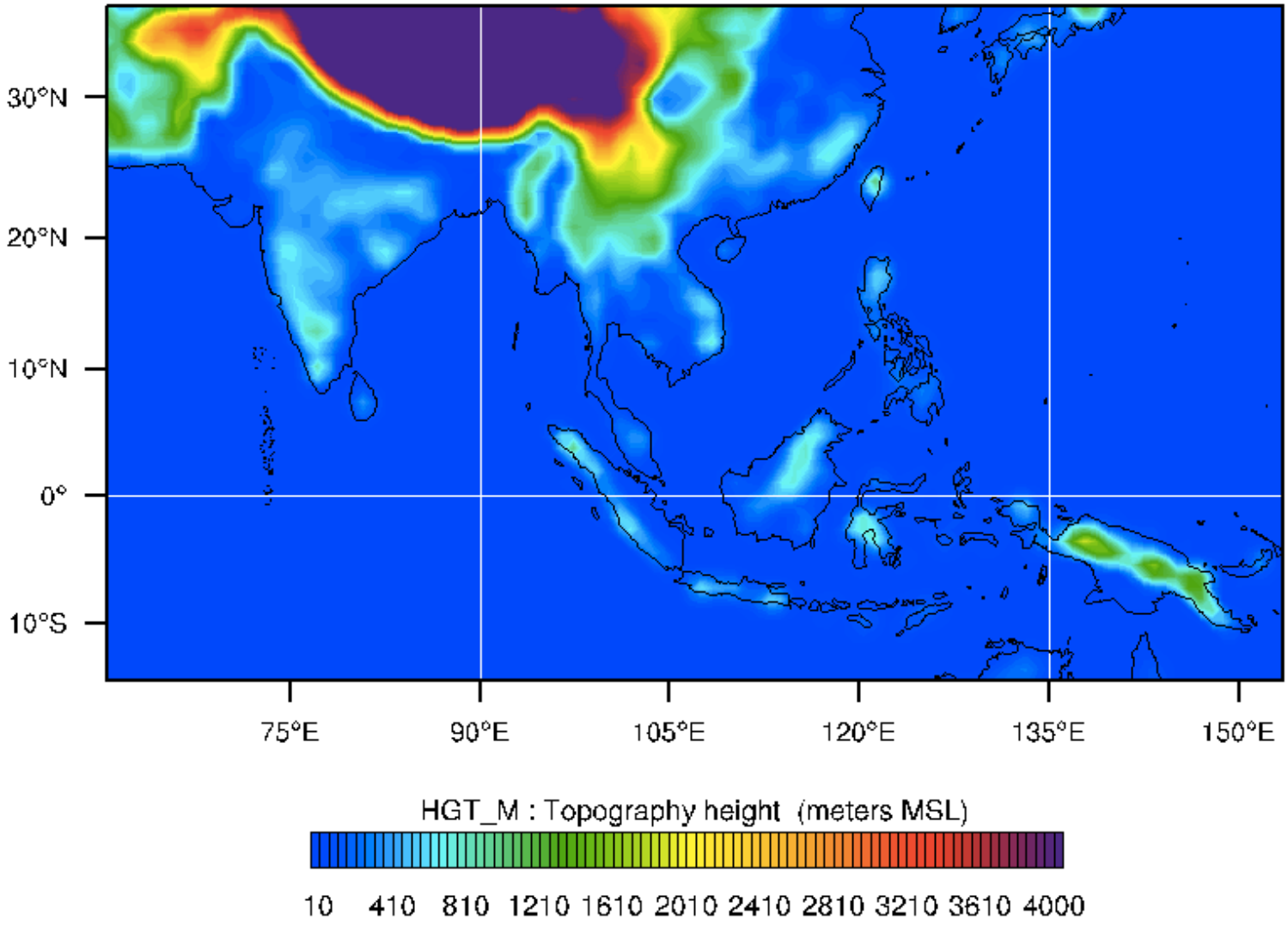


# Effect of TRUELAT

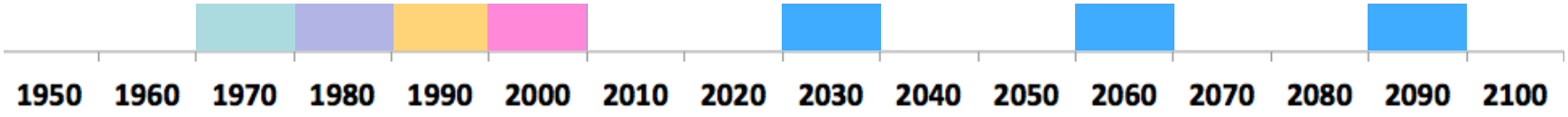
```
dx          = 50000,
dy          = 50000,
map_proj    = 'lambert',
ref_lat     = 40.0,
ref_lon     = -100.0,
truelat1    = 30.0,
truelat2    = 45.0,
stand_lon   = -100.0,
```

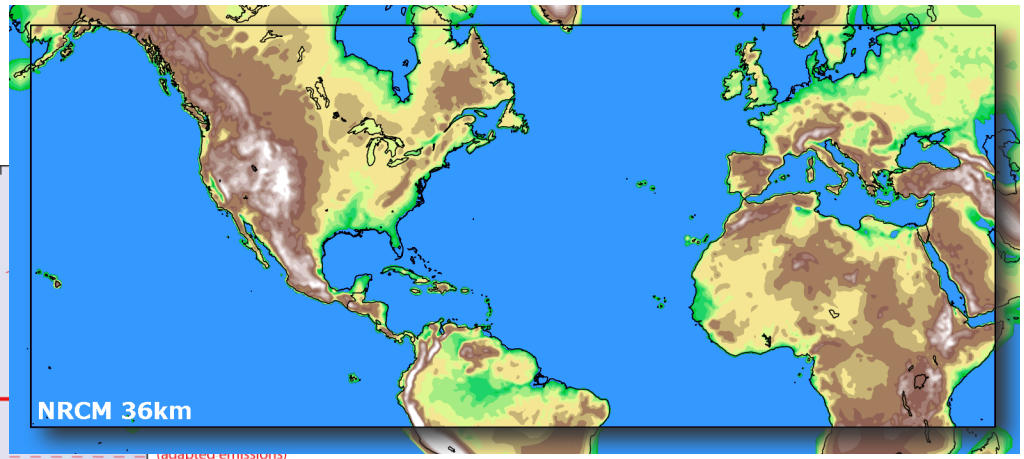


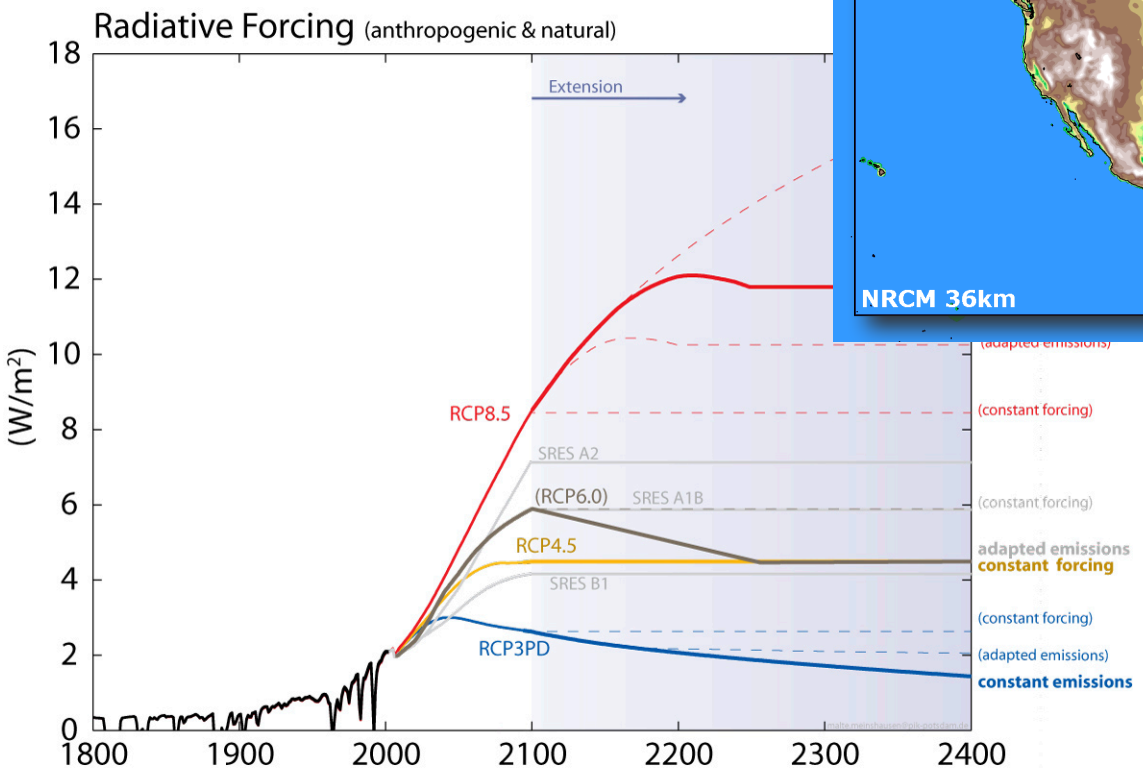
# Boundary Considerations



# Model Runs *(Long vs Time Slices)*

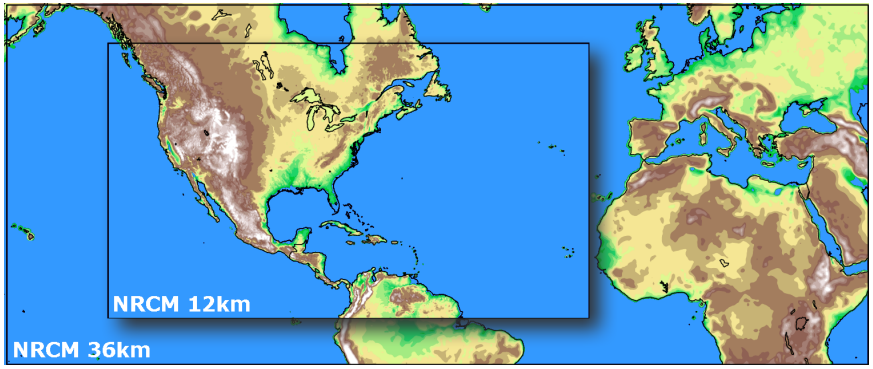


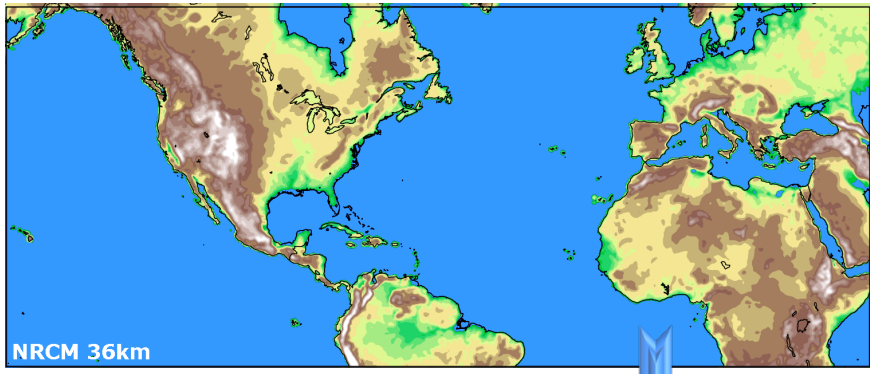



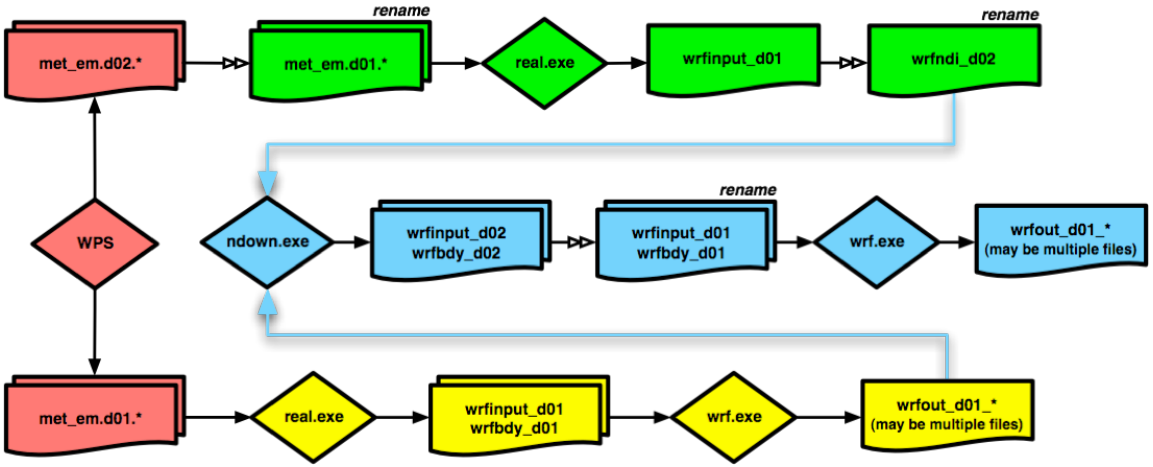



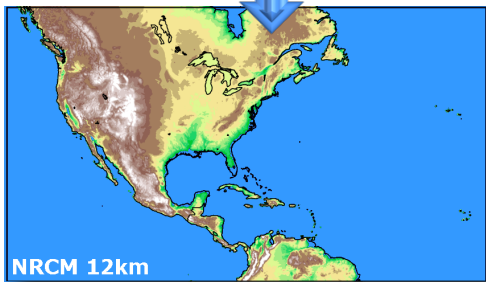

**36km domain**
**≈ 1mil CPU hours**
**per 10 year**
**simulation**

# Multiple nests



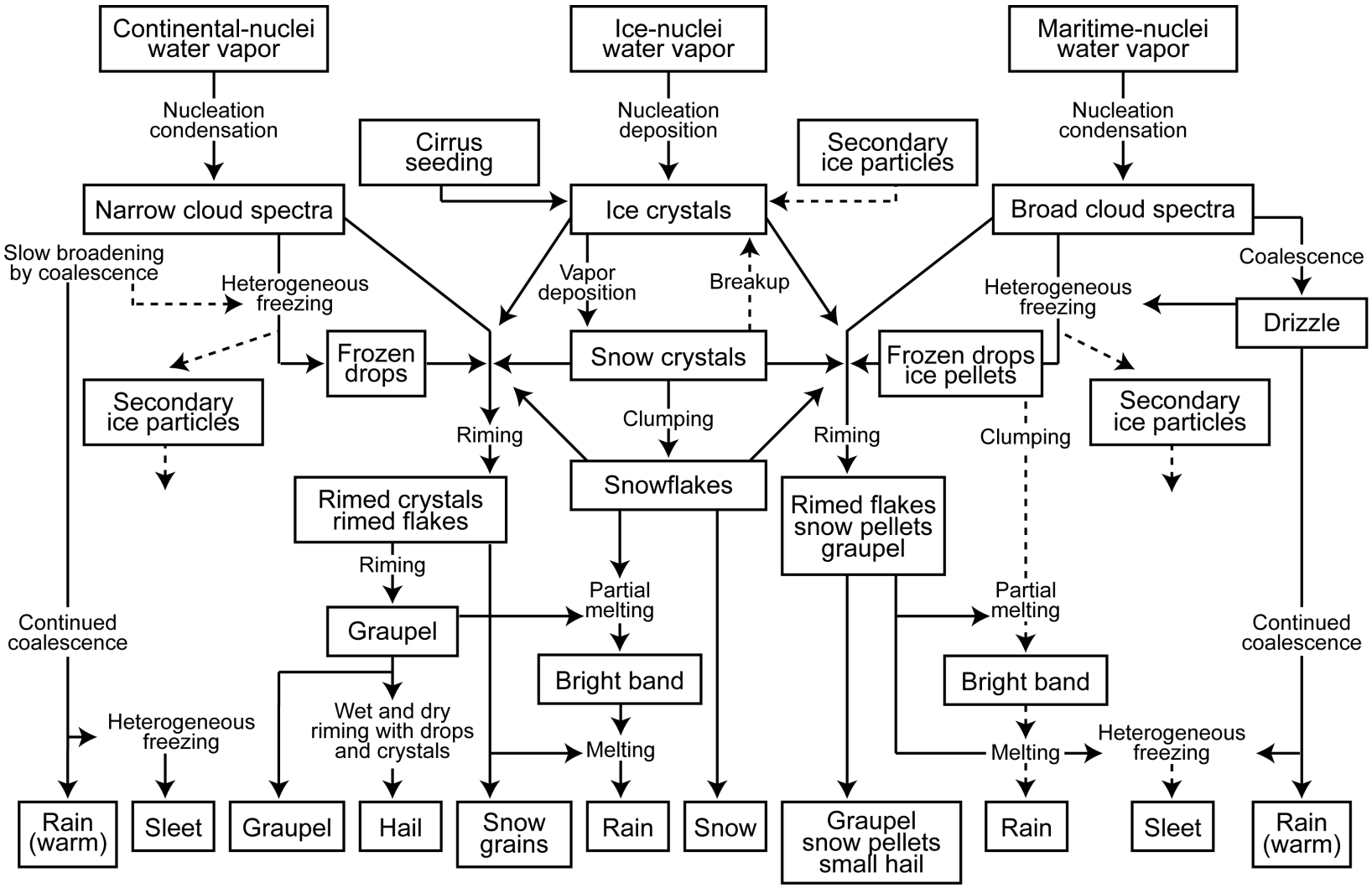




- **Only interested in running nest for short period**
- **Don't want upscaling effects**
- **Want to do analysis on domain 1 before deciding when/where to run domain 2**

# Physical Parameterizations



# Different Schemes, Different Results

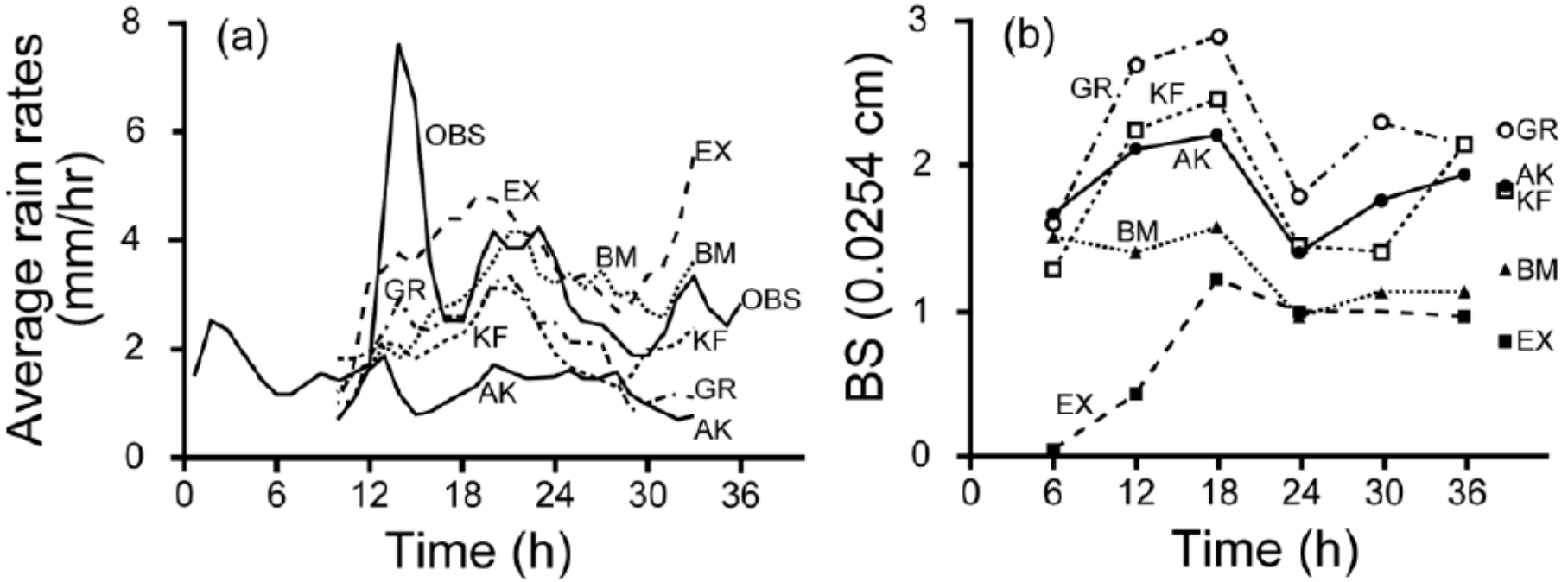
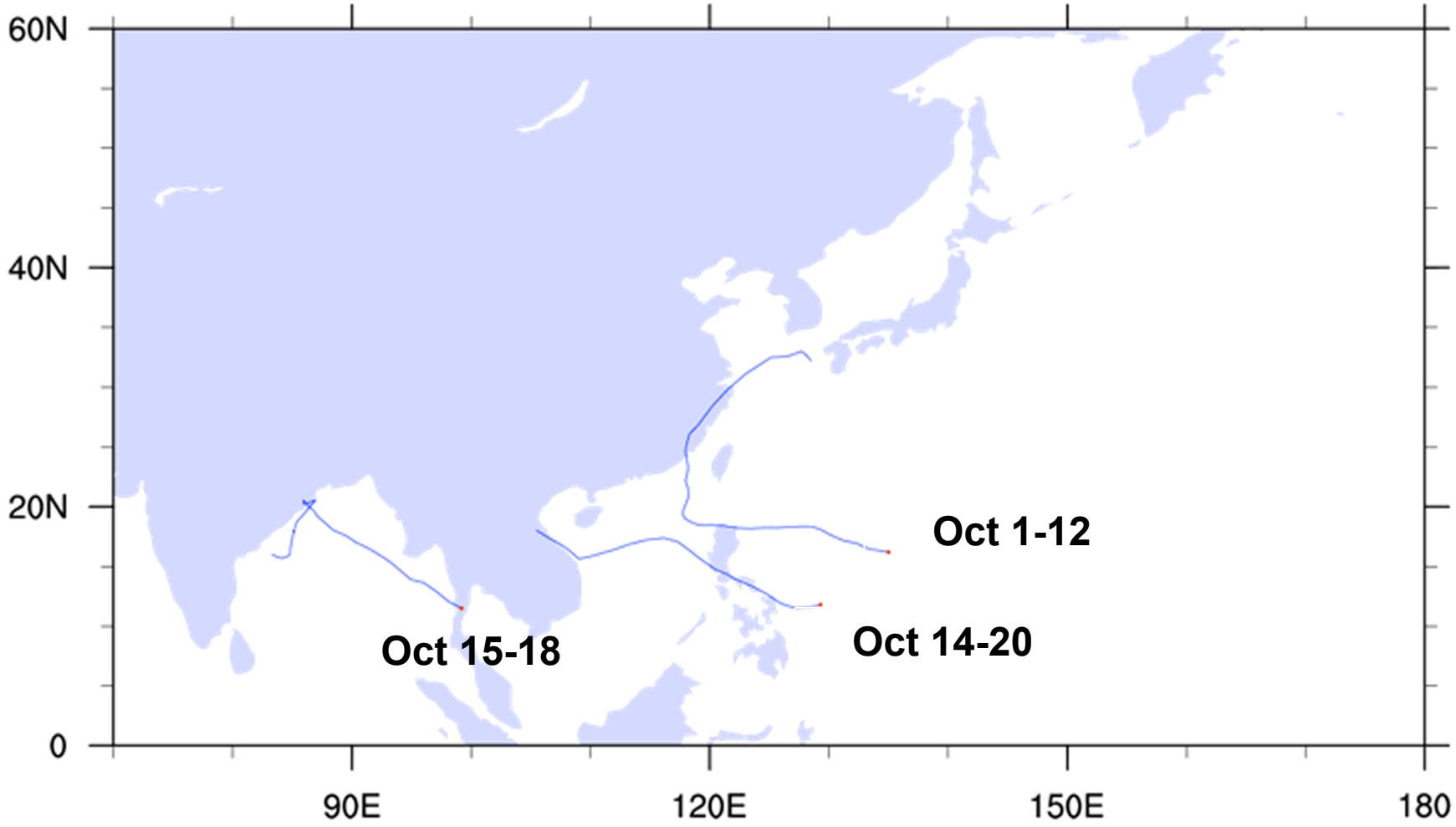


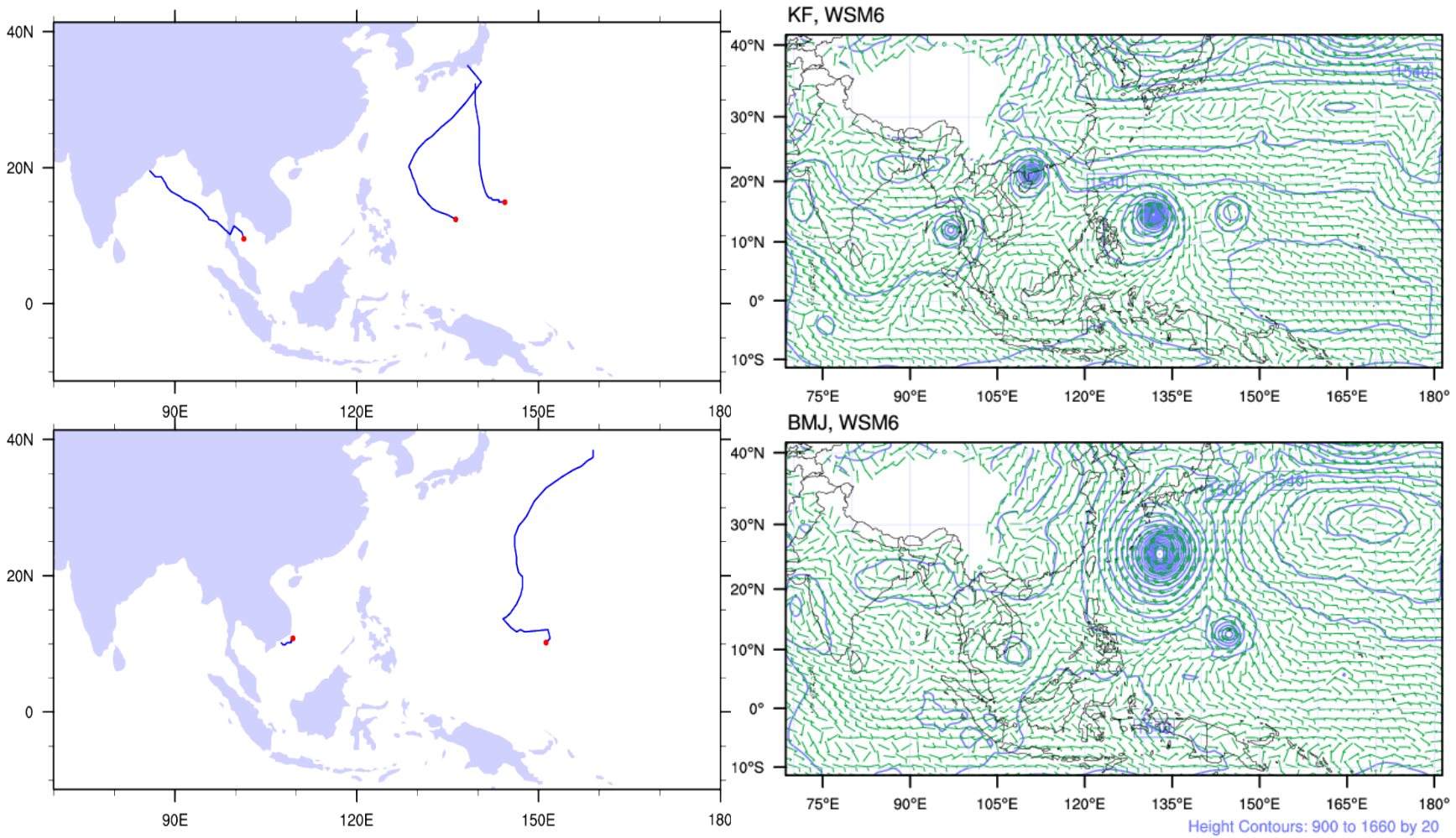

**Figure 4. Average rainfall rate, for a spring-season convective event (a), based on observations (OBS) and for five simulations that used different treatments for the convection - four different parameterizations, and no parameterization (EX). Also depicted is the rainfall rate bias score averaged for three warm-season convective events (b), again for each of the four parameterizations and for the use of no parameterization. The four convective parameterizations were the Grell (GR), Kain-Fritsch (KF), Betts-Miller (BM), and Anthes-Kuo (AK) schemes.**

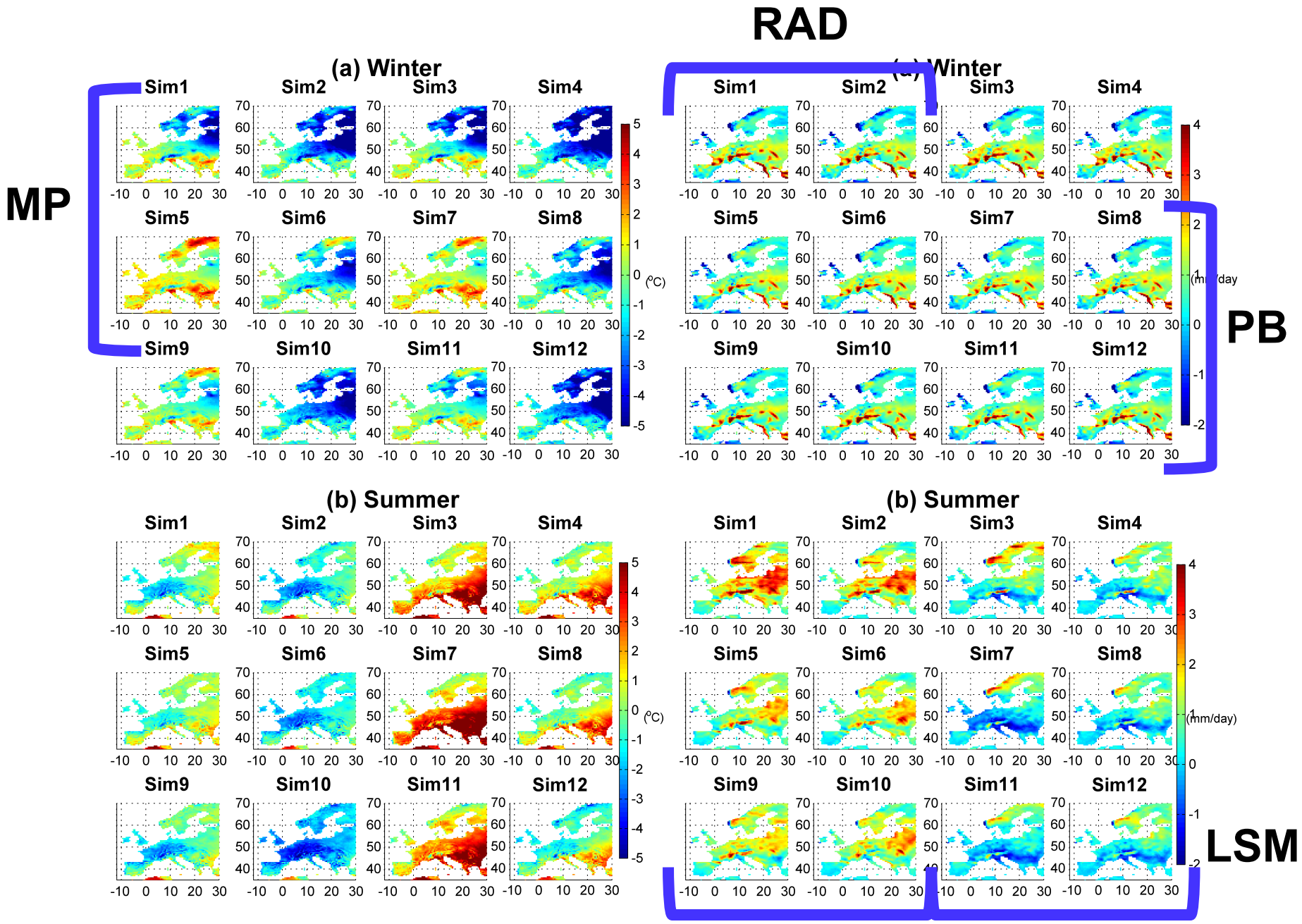
*Warner, 2011*

# Physics Considerations



# Physics Considerations

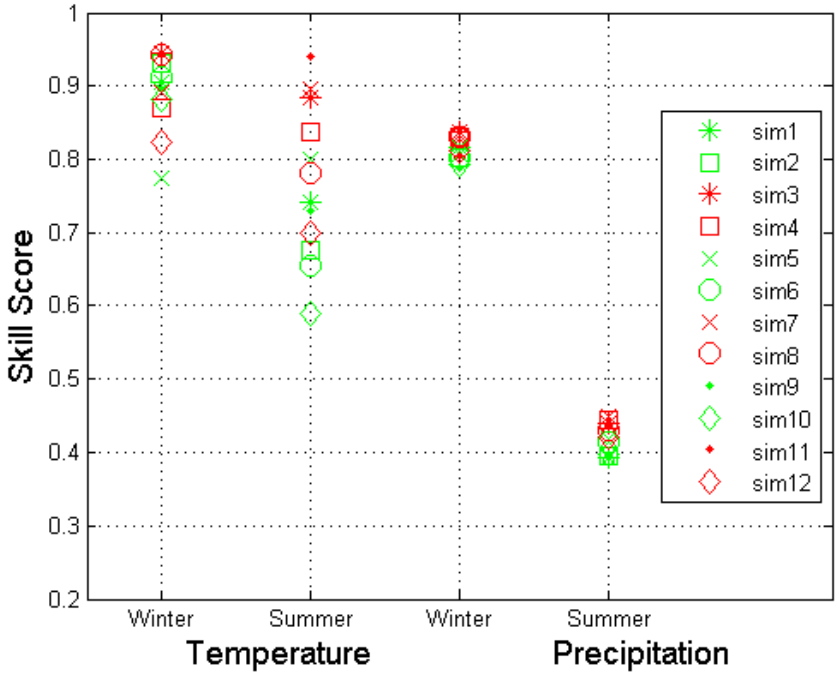




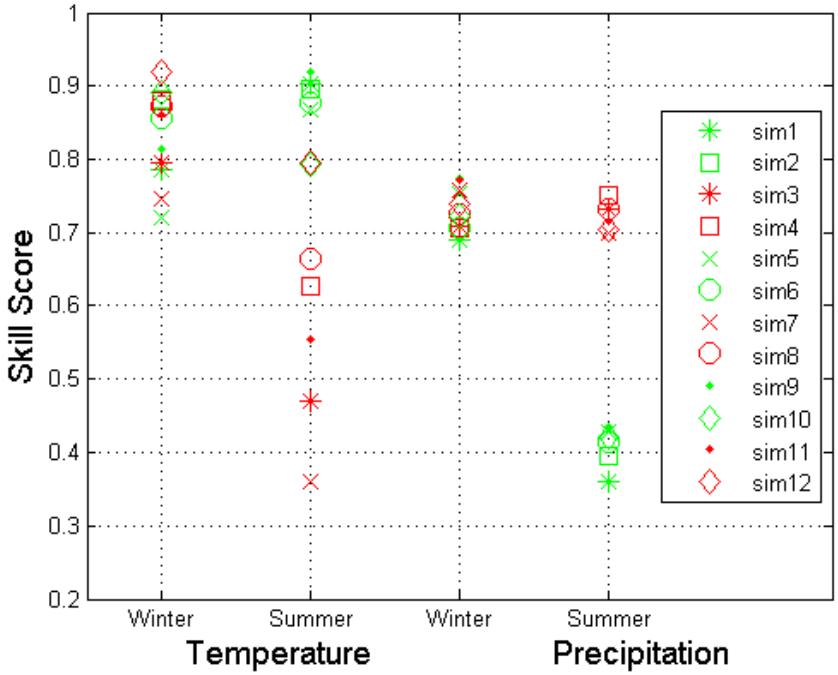

*Mooney et al. (JClim)*

# Physics Considerations

## British Isles

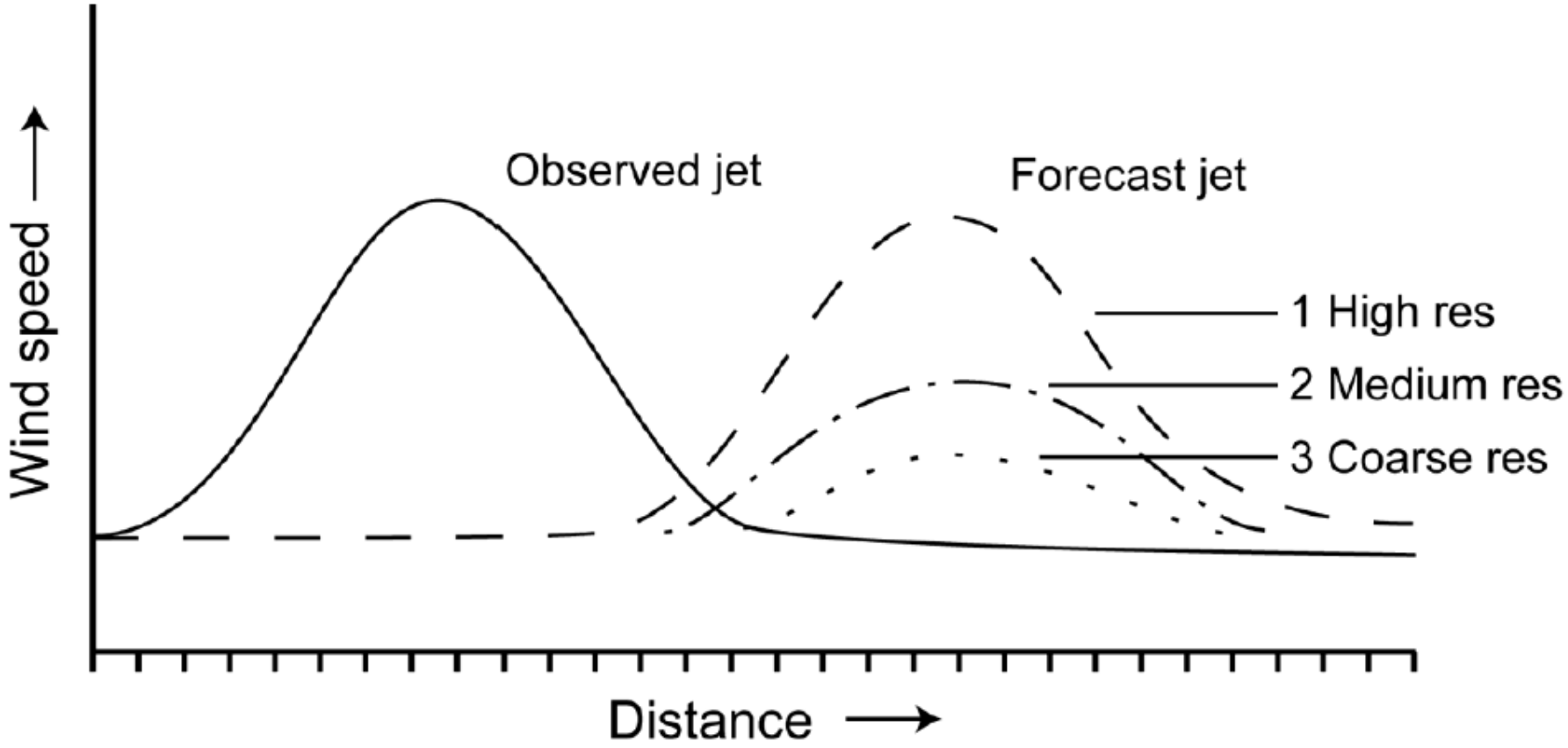



## Mediterranean

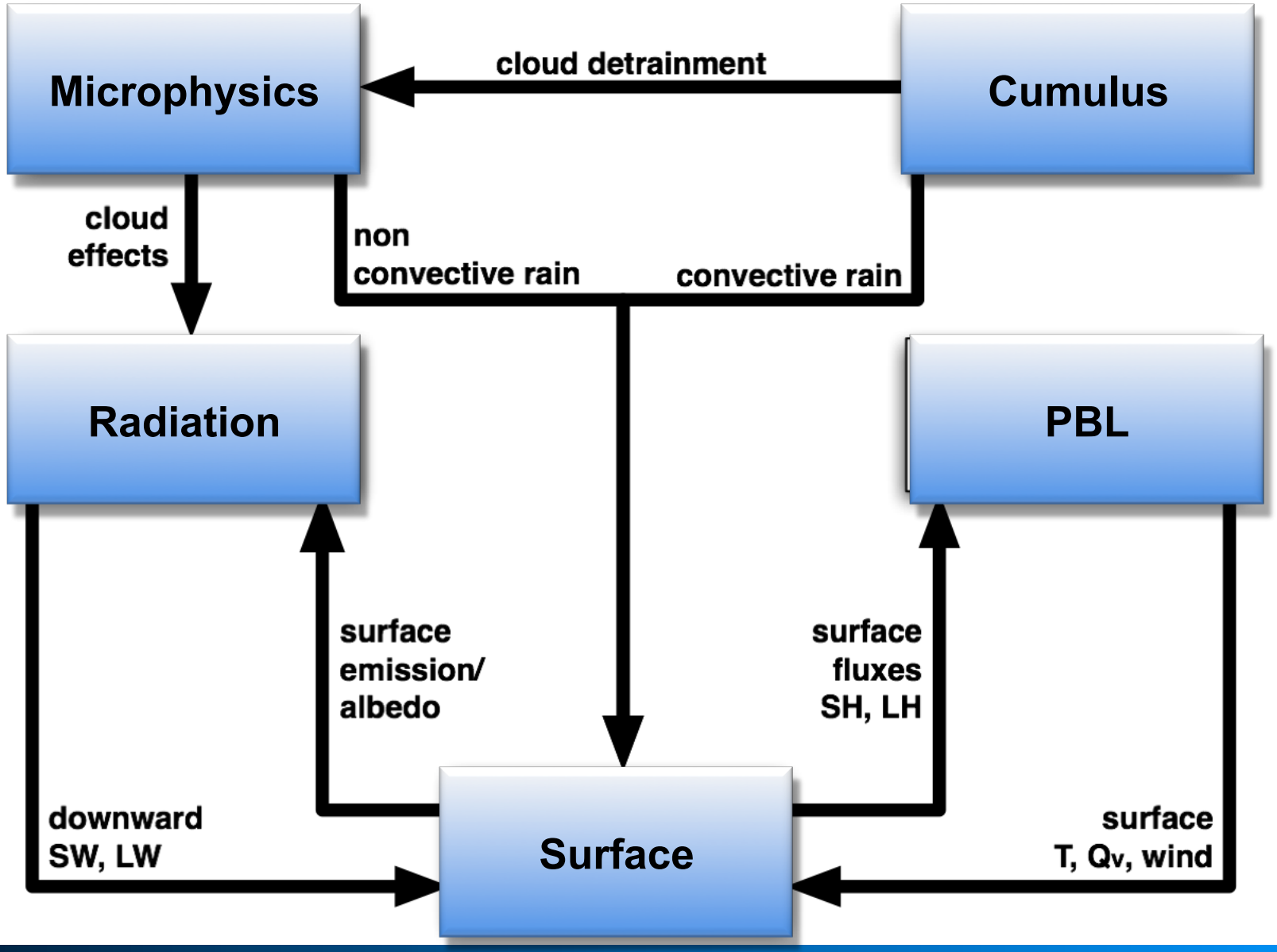



*Mooney et al. (JClim)*

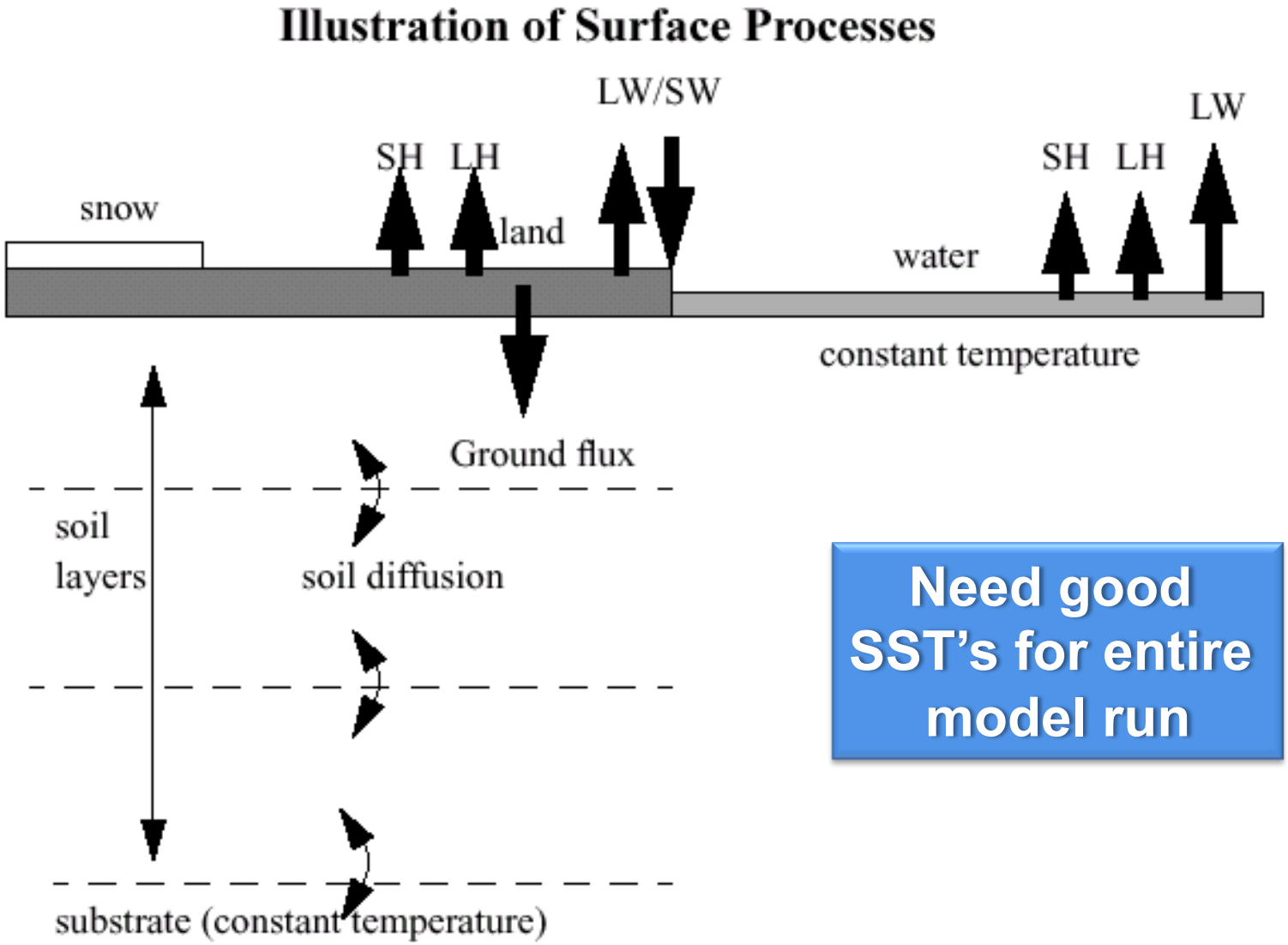
# Beware of Verification Metrics



# Interactions



# Atmosphere – Surface Interaction




**Need good SST's for entire model run**

# COAWST Modeling System

| | | |
|---|---|---|
| C | Coupled | MCT |
| O | Ocean | ROMS |
| A | Atmosphere | WRF |
| W | Wave | SWAN |
| ST | Sediment Transport | CSTMS |

USGS science for a changing world

Regional Ocean Modeling System ROMS Research Community

UNIVERSITY OF SOUTH CAROLINA

NCAR NATIONAL CENTER FOR ATMOSPHERIC RESEARCH

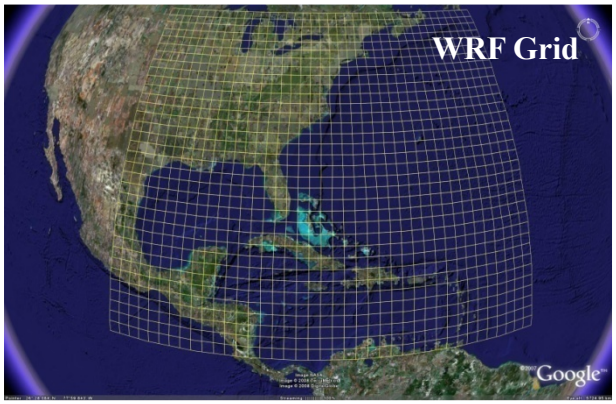
SWAN Simulating WAves Nearshore

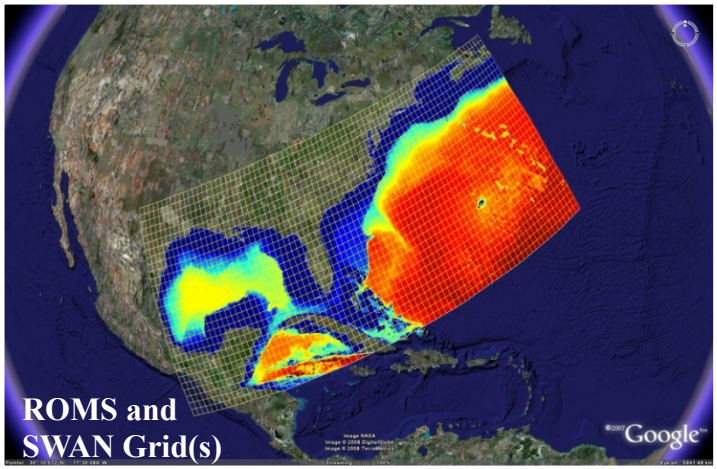
Georgia Institute of Technology Savannah

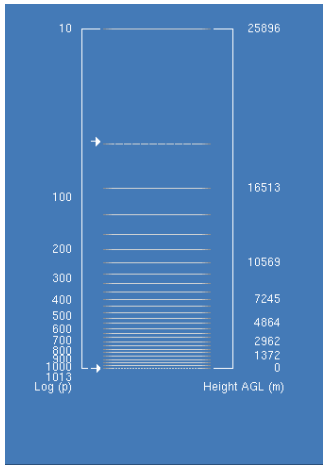
***http://woodshole.er.usgs.gov/operations/modeling/COAWST/***

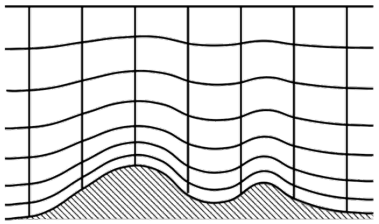
*John Warner*

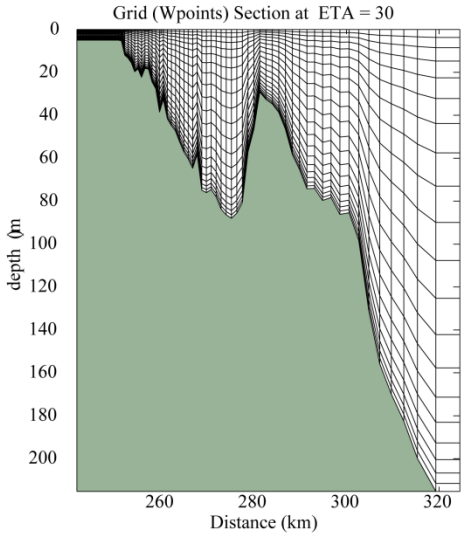
# Model Setup

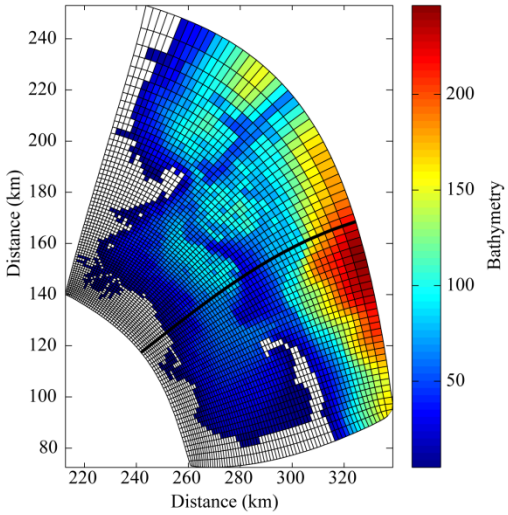

WRF Grid
Google


ROMS and
SWAN Grid(s)
Google

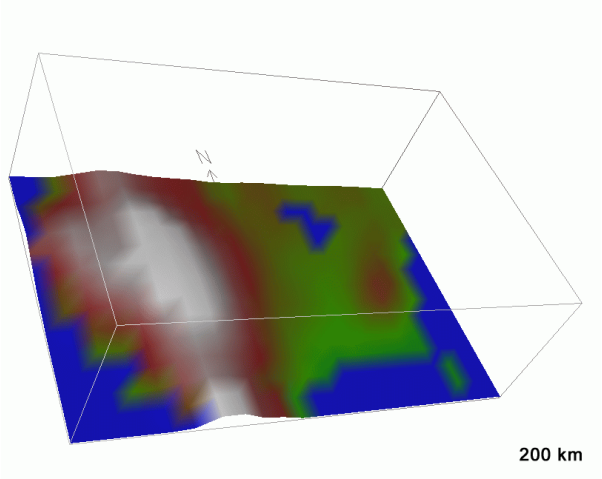

10
100
200
300
400
500
600
700
800
900
1000
1013
Log (p)
25896
16513
10569
7245
4864
2962
1372
0
Height AGL (m)

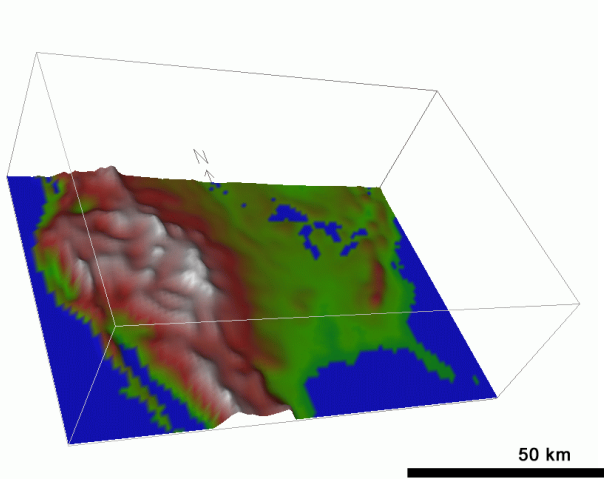


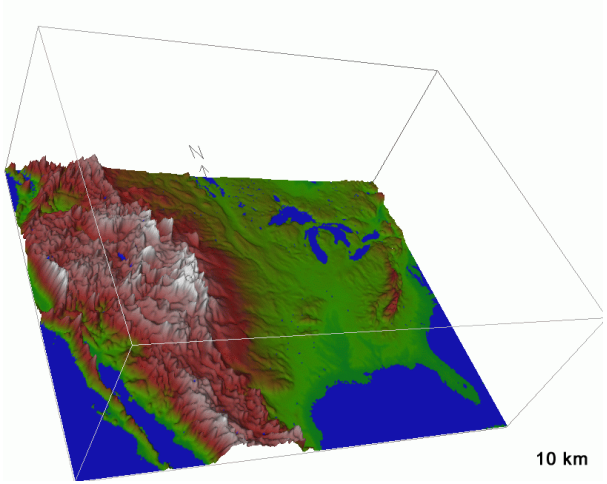

Grid (Wpoints) Section at ETA = 30
depth (m
0
20
40
60
80
100
120
140
160
180
200
260
280
300
320
Distance (km)

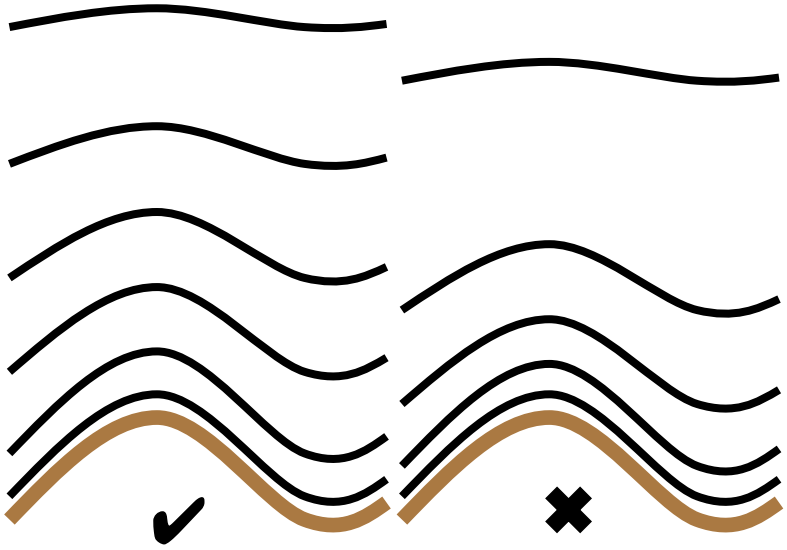

Distance (km)
240
220
200
180
160
140
120
100
80
220
240
260
280
300
320
Distance (km)
200
150
100
50
Bathymetry

# Resolution (Horizontal & Vertical)

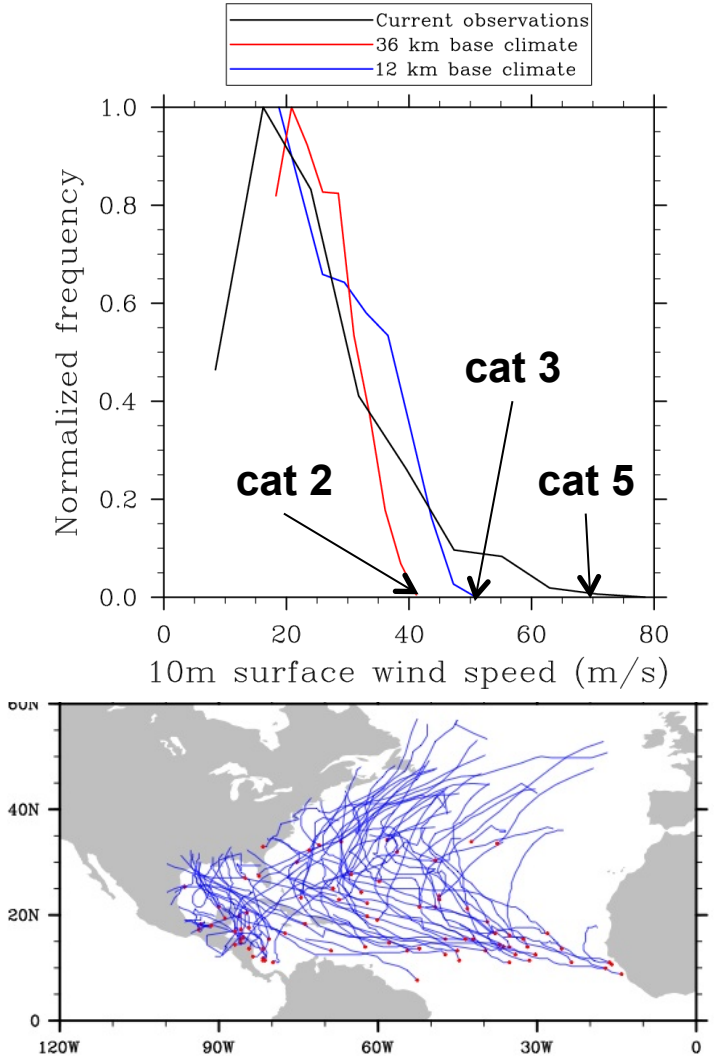


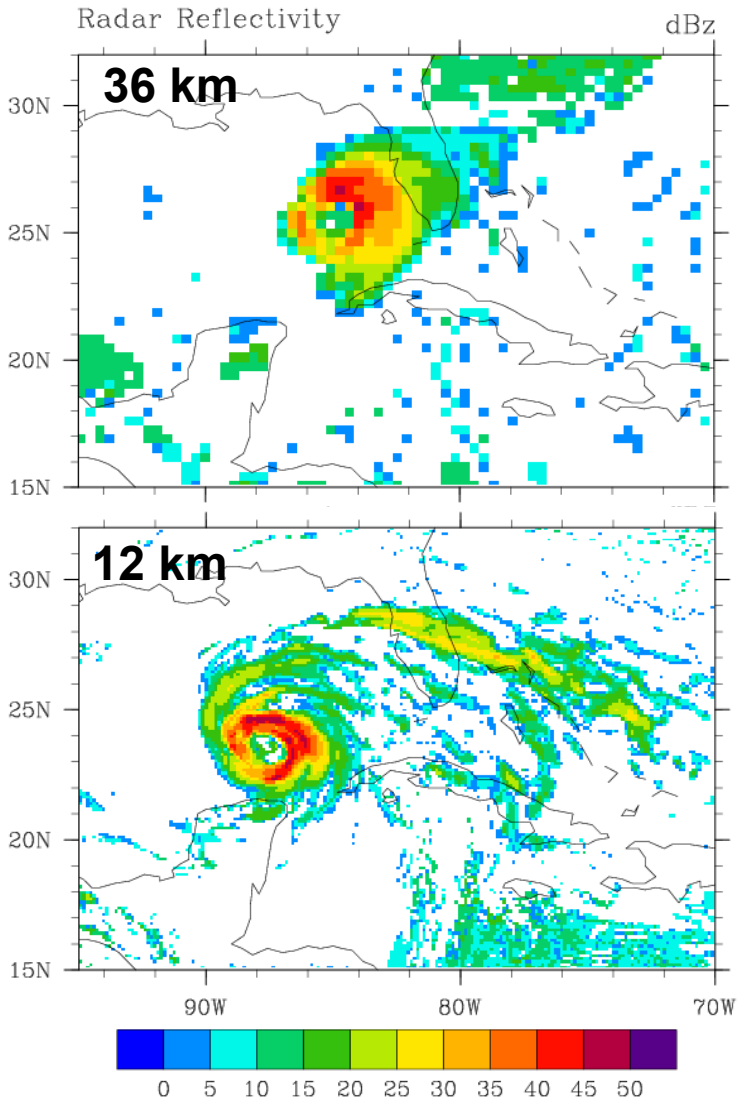



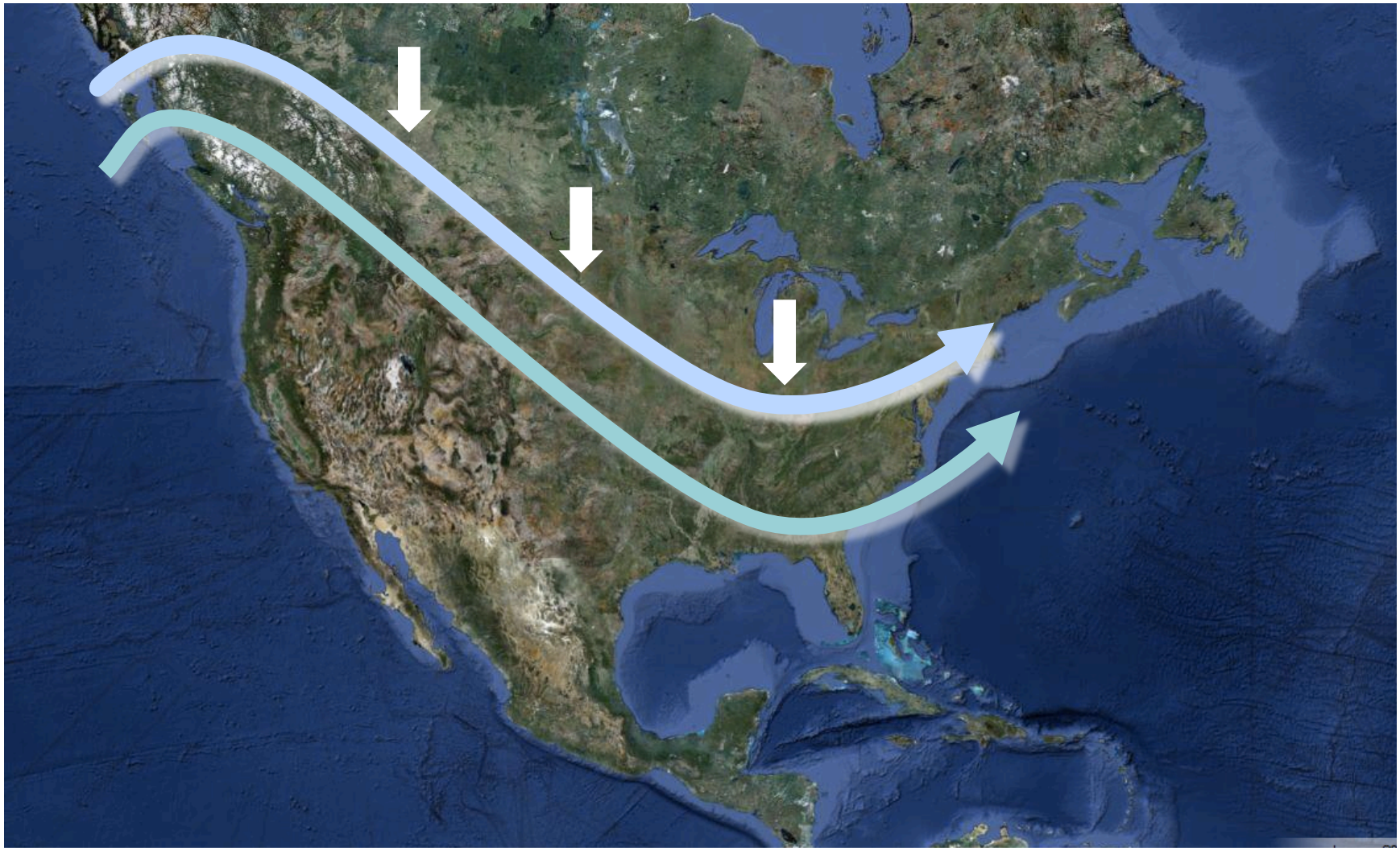



# Resolution


Current observations
36 km base climate
12 km base climate
Normalized frequency
1.0
0.8
0.6
0.4
0.2
0.0
cat 3
cat 2
cat 5
0
20
40
60
80
10m surface wind speed (m/s)
60N
40N
20N
0
120W
90W
60W
30W
0


Radar Reflectivity
dBz
36 km
12 km
30N
25N
20N
15N
90W
80W
70W
0
5
10
15
20
25
30
35
40
45
50

# Concept of Nudging

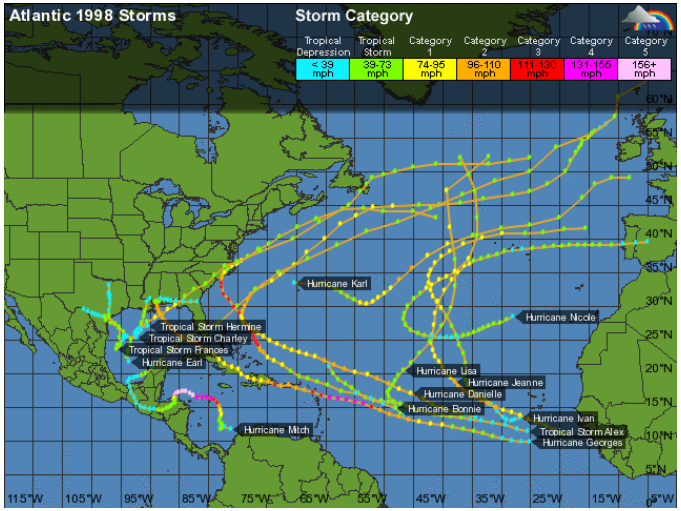


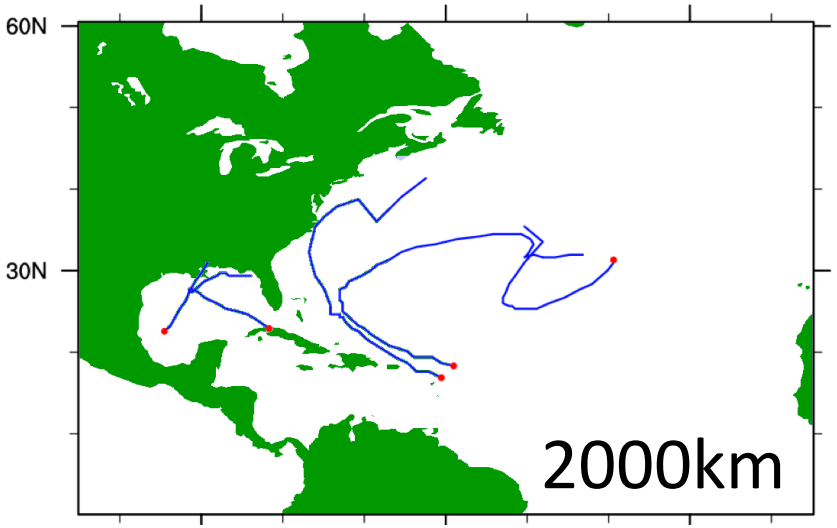
# Nudging - Motivation

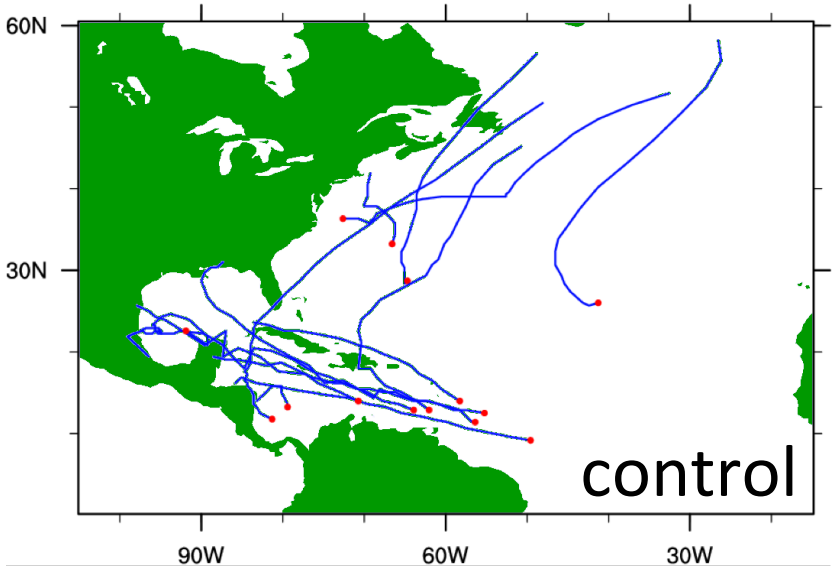
- Climatologist often use nudging when downscaling global climate data to keep the model "on-track" and provide better climate statistics.
  - "One-to-one hurricane climate statistics"

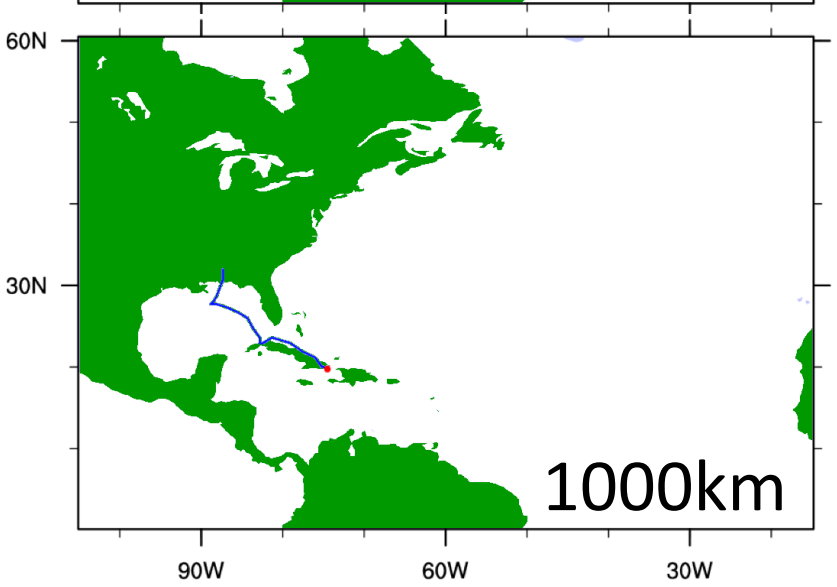
- This could potentially impair results
  - Global data does not correctly represent waves
  - Model not able to spin up own climate
  - Model not able to spin up small scale features

# Nudging – An Example



# WRF: namelist.input

```
&time_control
  auxinput4_inname    = "wrflowinp_d<domain>"
  auxinput4_interval = 360, 360, 360,
  io_form_auxinput4   = 2

&physics
  sst_update          = 1,
```

```
&time_control
  output_diagnostics = 1,

&physics
  sst_skin            = 1,
  tmn_update          = 1,
```

**output_diagnostics : outputs max/min/mean/std of surface fields**

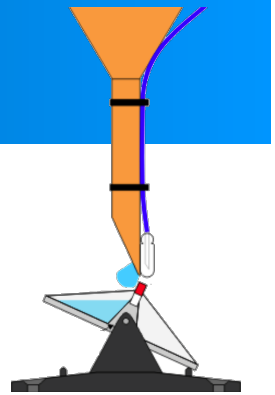
**sst_skin: adds a diurnal cycle to the sea-surface temperature**

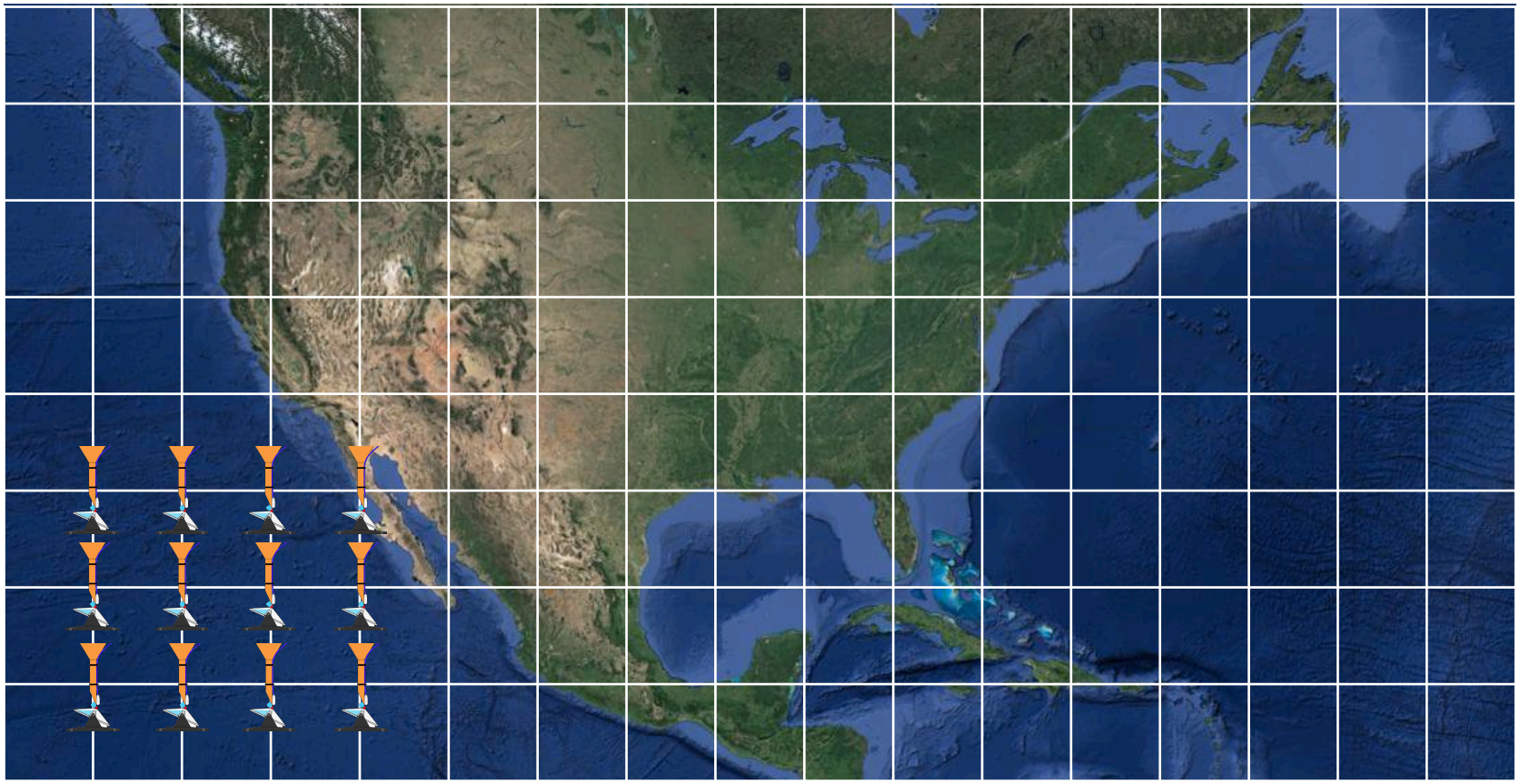
**tmn_update: updates deep soil temperature**

# WRF: namelist.input

```
bucket_mm       = 100,
bucket_J        = 1.e9,
```

```
RAINC + 100.*I_RAINC
RAINNC + 100.*I_RAINNC
```





# WRF: namelist.input – bdy_control

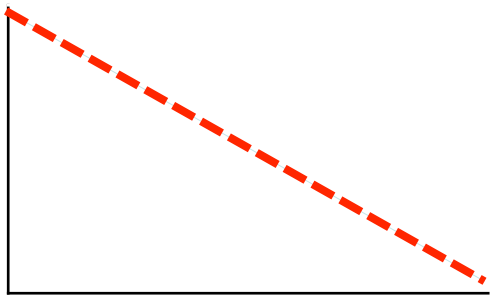
```
spec_zone          = 1,
relax_zone         = 9,
spec_bdy_width     = 10,
spec_exp           = 0.33
```

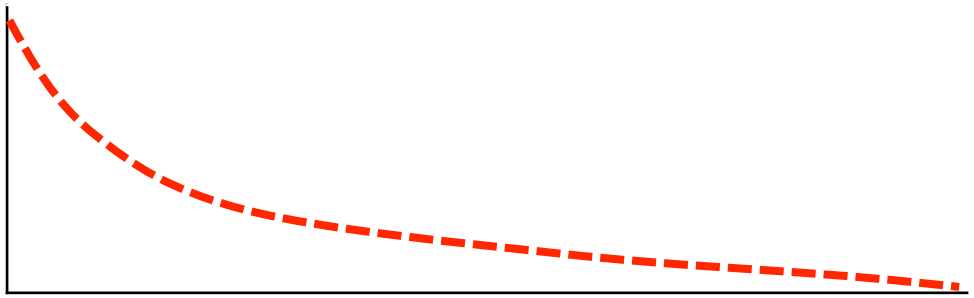
**spec_zone: MUST be 1**

**relax_zone: Default is 4. Climate runs often larger (9)**

**spec_bdy_width: Sum of top two**

**spec_exp: Typically only used for wide (10) boundaries. Exponential weight in boundary**

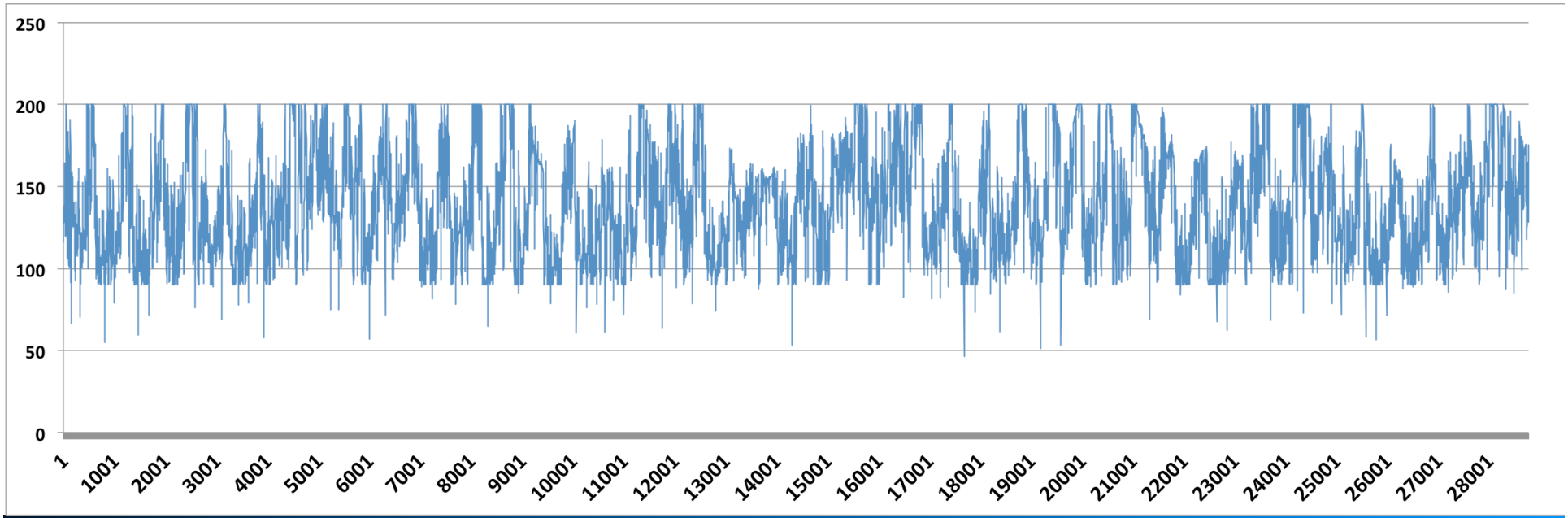




# WRF: namelist.input – adaptive time stepping

```
use_adaptive_time_step = .true.,
step_to_output_time    = .true.,
target_cfl             = 1.2, 1.2,
target_hcfl            = .84, .84,
max_step_increase_pct  = 5,   51,
starting_time_step     = -1,  -1,
max_time_step          = 200, 120,   (~8*dx)
min_time_step          =  90,  30,   (~4*dx)
```

**dx = 36**
**dt: 288 - 144**



# Useful References


- Done, J.M., Holland, G.J., Bruyère, C.L., Leung, L.R., and Suzuki-Parker, A., 2012: Modeling high-impact weather and climate: Lessons from a tropical cyclone perspective. NCAR/TN-490+STR, 28pp. http://nldr.library.ucar.edu/repository/collections/TECH-NOTE-000-000-000-854

- Warner, Thomas T., 2011: Quality Assurance in Atmospheric Modeling. *Bull. Amer. Meteor. Soc., 92, 1601–1610.doi: http://dx.doi.org/10.1175/BAMS-D-11-00054.1*

# Publications


- Bruyère C.L., J.M. Done, G.J. Holland, and S. Fredrick, 2013: Bias Corrections of Global Models for Regional Climate Simulations of High-Impact Weather, *In Review.*
- Bruyère C.L., G.J Holland, E. Towler, 2012: Investigating the use of a Genesis Potential Index for Tropical Cyclones in the North Atlantic Basin, J. Climate, 25, 8611–8626.
- Done, J.M., G.J. Holland, C.L. Bruyère, L.R. Leung, and A. Suzuki-Parker, 2012: Modeling high-impact weather and climate: Lessons from a tropical cyclone perspective. NCAR Technical Note NCAR/TN-490+STR, DOI: 10.5065/D61834FM.
- Done. J.M., G.J. Holland, and P. Webster, 2011: The role of wave energy accumulation in tropical cyclogenesis over the tropical North Atlantic, Clim. Dyn., 36, 753-767.
- Done, J., G.J., Holland, C.L. Bruyère, and A. Suzuki-Parker, 2011: Effects of Climate Variability and Change on Golf of Mexico Tropical Cyclone Activity. Paper OTC 22190 presented at the Offshore Technology Conference, Houston, Texas, 2-5 May.
- Done J.M., G.J. Holland, C.L. Bruyère, L.R. Leung, and A. Suzuki-Parker, 2013: Modeling High-Impact Weather and Climate: Lessons from a Tropical Cyclone Perspective, *Accepted in Climatic Change*.
- Galarneau, T. J., Jr., 2013: Synoptic-Scale Influences on Subseasonal and Interannual Variability in African Easterly Wave Activity. *In preparation for Journal of Climate.*
- Holland G.J., and C.L. Bruyère, 2013: Recent intense hurricane response to global climate change, *Climate Dynamics*, 10.1007/s00382-013-1713-0.

# Publications


- Holland, G.J., J.M. Done, C.L. Bruyère, C. Cooper and A. Suzuki, 2010: Model Investigations of the Effects of Climate Variability and Change on Future Gulf of Mexico Tropical Cyclone Activity. Paper OTC 20690 presented at the Offshore Technology Conference, Houston, Texas, 3-6 May.
- Hsu, H-M., J.J. Tribbia, M.W. Moncrieff, and C.L. Bruyère, 2013: Multiscale Spectral Structure of Maritime Continent Rainfall Simulated by a Nested Regional Climate Model and Observed by Satellites. *Climate Dynamics, Accepted.*
- Ray P, C Zhang, M Moncrieff, J Dudhia, JM Caron, LYR Leung, and C Bruyère. 2011: Role of the Atmospheric Mean State on the Initiation of the Madden-Julian Oscillation in a Tropical Channel Model. *Climate Dynamics 36(1-2):161-184. doi:10.1007/s00382-010-0859-2.*
- Rasmussen, R., K. Ikeda, C. Liu, D. Gochis, M. Clark, A. Dai, E. Gutmann, J. Dudhia, F. Chen, M. Barlage, C.L. Bruyère, and D. Yates, 2013: The Impact of Climate Change on the Water Balance of the Colorado Headwaters: High Resolution Regional Climate Model Simulations. *Submitted to J. of Hydrometeology*.
- Suzuki-Parker, A., 2012: An assessment of uncertainties and limitations in simulating tropical cyclones. Springer Thesis. XIII, 78 pp.
- Towler E., V. Saab, R. Sojda, K. Dickinson, C.L. Bruyère, and K. Newlon, 2012: A risk-based approach to evaluating wildlife demographics for adaptation: A case study of the Lewis's Woodpecker, *Environmental Management,* 50, 1152-1163.