Advanced Summer School

Ocean and Atmosphere Modeling

Atmospheric Modeling:

Introduction to the Weather Research and Forecasting (WRF) modeling system

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FOREWORDS: WHAT IS WRF ?

WRF: **Weather Research and Forecasting Model**
Used for both for Research and Meteo services (operational forecast with data assimilations).

It is a **community model** like CROCO for the ocean, i.e., free and shared resources. Design for regional mesoscale configurations (1 to 10 km) but other applications can be done.
Development led by NCAR with collaboration with numerous universities all over the world.

- Applications:
(i) Research and physical process studies
(ii) Idealized configuration
(iii) Weather forecasting and Public agencies
(iv) etc.

Contents

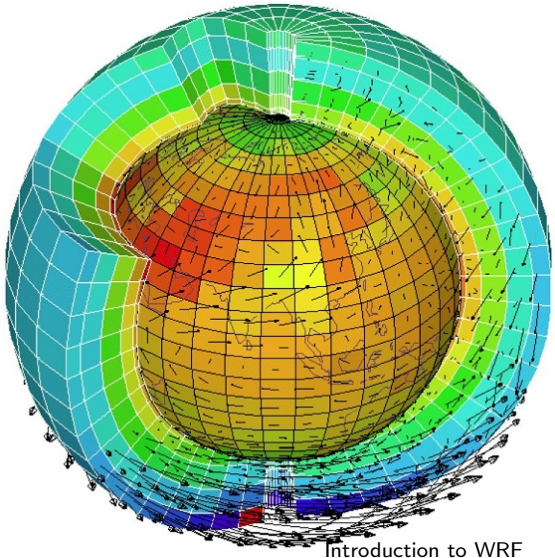
Earth modeling system

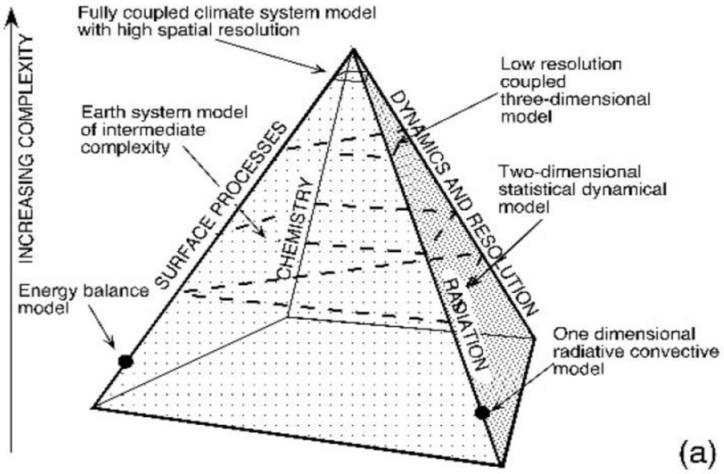
$\Longrightarrow$ Global atmosphere models were originally developed as a mean of understanding general circulation of the atmosphere (large pressure pressure systems, winds, moisture, etc.)

$\Longrightarrow$ Later Ocean, Cryosphere (ice), Chemistry, Biology, etc. has been developed based on the early development of atmospheric models.

$\Longrightarrow$ Both standalone and Coupled Earth system models have been used for **weather prediction** and **Climate variability**.

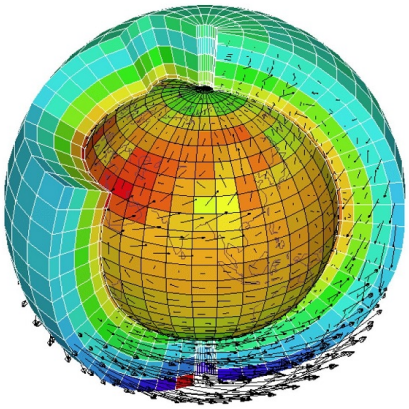
Drivers of Weather Vs. Drivers of Climate





Model Complexity

A climate model pyramid showing increasing complexity in GCMs on the vertical axis and the primary processes that interact with each other along the outlines: radiation, dynamics, resolution, chemistry and surface processes (adopted from McGuffie et al., 2011).



Some numbers

How many calculations a 'simple'** atmospheric standalone have to perform ??

→ Let's consider a global model at $2.5°$ of horizontal resolution: ~ 10000 cells

→ 30 vertical levels: ~ 300000 grid boxes

→ Primitive equations at there simplest versions: 7 unknowns, ~ 2.1 million variables

→ Let's assume a low estimate of 20 calculations by variables: 42 million of calculations

→ Half an hour time step: about 2 billion calculations a day

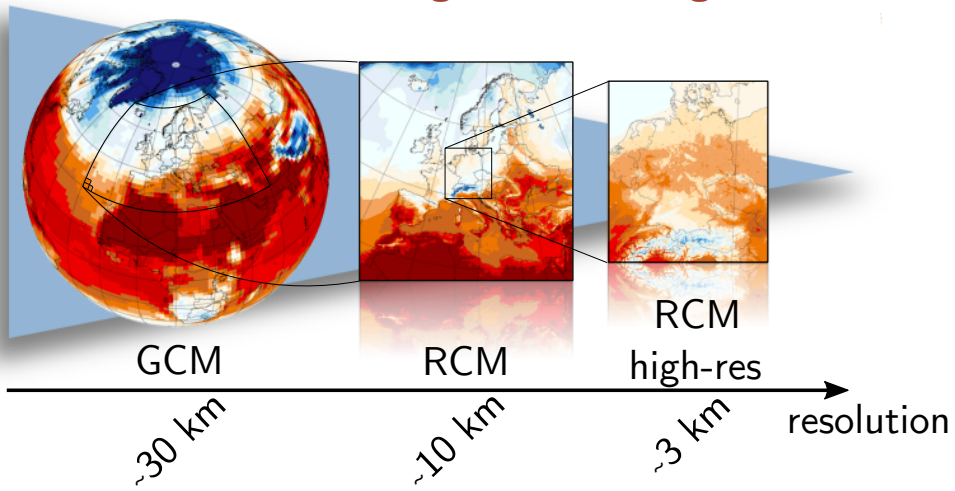
→ 100 yrs of climate simulations: about 73 trillion calculations

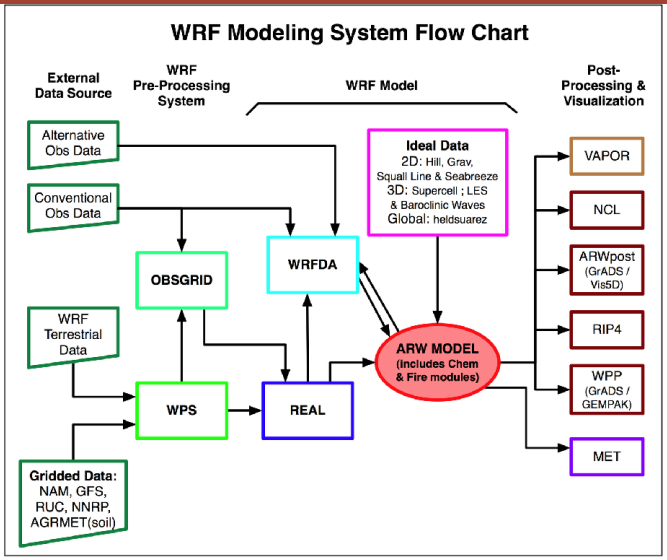
$\Longrightarrow$ Atmospheric models are usually more expensive for a given grid size than ocean models due to faster dynamics and more complex parametrizations (e.g., radiation, microphysics, etc)

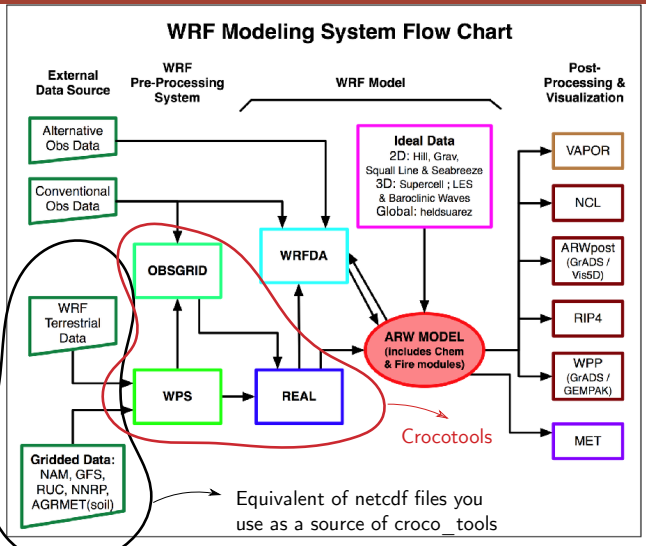
**No chemistry, prognostic aerosols, no upper atmosphere

Adapted from Steven Sherwood

Regional Modeling




WRF Modeling System Flow Chart
External Data Source
WRF Pre-Processing System
WRF Model
Post-Processing & Visualization
Alternative Obs Data
Conventional Obs Data
Ideal Data
2D: Hill, Grav, Squall Line & Seabreeze
3D: Supercell ; LES & Baroclinic Waves
Global: heldsuarez
VAPOR
NCL
ARWpost (GrADS / Vis5D)
RIP4
WPP (GrADS / GEMPAK)
MET
OBSGRID
WRFDA
WRF Terrestrial Data
ARW MODEL (Includes Chem & Fire modules)
WPS
REAL
Gridded Data: NAM, GFS, RUC, NNRP, AGRMET(soil)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Crocotools
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Equivalent of netcdf files you use as a source of croco_tools

WRF Grids

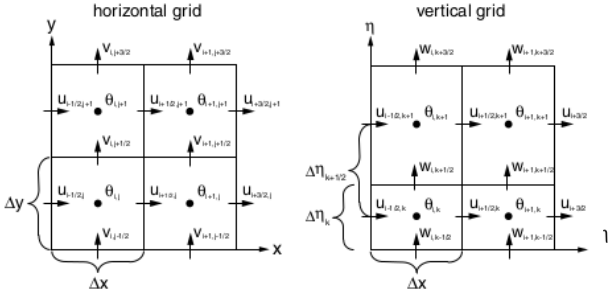


Fig. 3. Horizontal (left) and vertical (right) staggering for the C-grid.

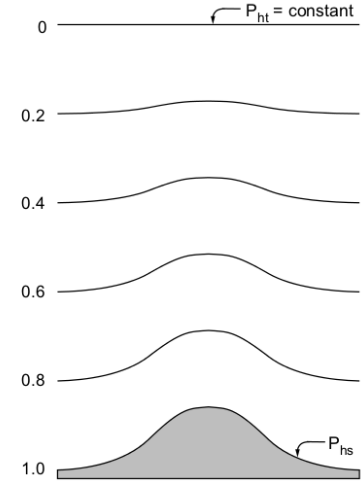
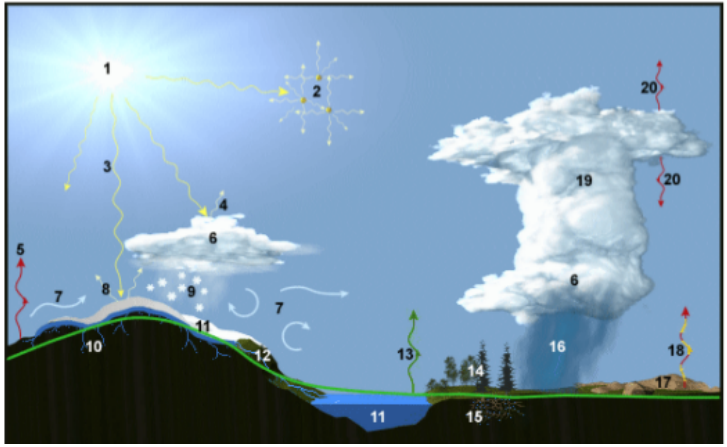


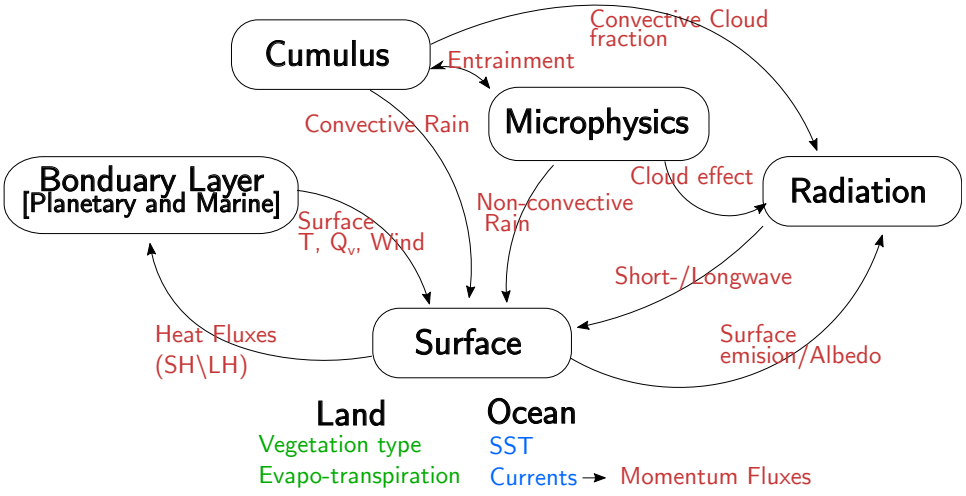
Fig. 1. Schematic of the terrain following σ coordinate.

WRF Processes



1. Incoming Solar Radiation
2. Scatering by Aerosols
3. Atmosphere Absorption
4. Reflection/Absorption by Clouds
5. LW (grey body)
6. Condensation
7. Turbulence
8. Reflection/Abs. by Earth surface
9. Snow
10. Snow melt/ Soil Water
11. SnowIce / Water Cover
12. Topography
13. Evaporation
14. Vegetation
15. Soil properties
16. Rain
17..Surface Roughness
18. Sensible heat fluxes
19. Deep Convection
20. LW from Clouds

Direct Interactions of Parametrizations



Main physical Parametrization

$\Longrightarrow$ Convection

$\Longrightarrow$ Clouds Microphysics

$\Longrightarrow$ Turbulence

$\Longrightarrow$ Radiation

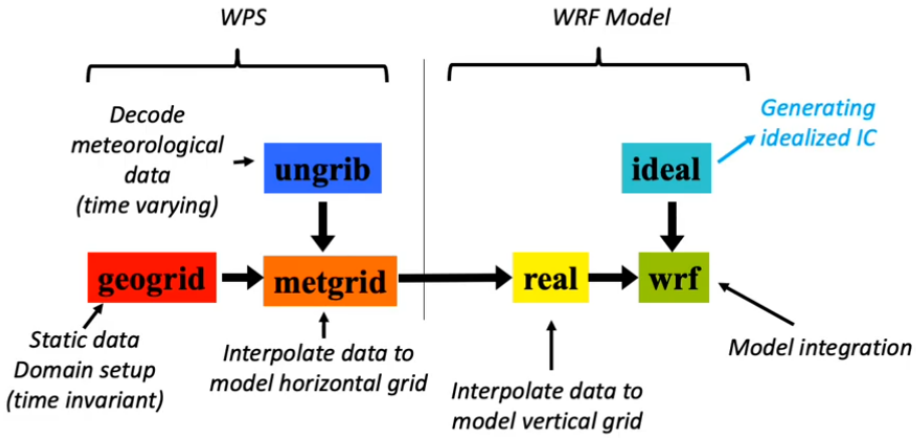
$\Longrightarrow$ Land Surface Model

$\Longrightarrow$ Boundary Layer

Namelists: equivalent to croco.in + cppdefs.h

Exemple here (click)

WRF for the users



Online Tutorial: https://www2.mmm.ucar.edu/wrf/OnLineTutorial/index.php

Main physical Parametrization

$\Longrightarrow$ Compile Just once

*** Preprocessing ***
$\Longrightarrow$ Set the namelist.wps $\Longrightarrow$ Run geogrid.exe : grid files

$\Longrightarrow$ Run ungib.exe : Decode time varaying Met data (creation of 'intermediate' files)

$\Longrightarrow$ Run metgid: Interpolate the intermediate files to model horizonal grid

*** end of preprocessing ***

$\Longrightarrow$ Set the namelist.wrf (set the param choices)
$\Longrightarrow$ Run real.exe : interpolation on the vertical grid, creation of wrfbdy.nc, wrfinput.nc and wrflowinput.nc
$\Longrightarrow$ Run the model

Some Refs