Model for Prediction Across Scales-Atmosphere (MPAS-A)
A first view in the Mediterranean basin
Alex Montornès

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MPAS-A: A first view in the Mediterranean basin
Atmospheric modeling 90s and 2000s: LAM nesting
Limited area models as WRF

Structured C-grid staggering

Projections

Mercator
Lambert conformal
Polar stereographic
Limited area models as WRF

Structured C-grid staggering

Projections

Mercator
Lambert conformal
Polar stereographic

Global WRF

Source: MPAS tutorial
Limited area models as WRF

Structured C-grid staggering

Projections

Global WRF

Deformation due to projections.

Nesting approach :: seamless model limitation

Poor interaction between scales (1-way/2-way nesting)

Polar issues

Source: MPAS tutorial
Unstructured grid: a different approach

Unstructured C-grid staggering

Variable resolution

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MPAS-A: A first view in the Mediterranean basin
Unstructured grid: a different approach

Unstructured C-grid staggering

- Projection is not required
- Seamless modeling chain (without nesting)
- No polar issues

Variable resolution

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MPAS-A: A first view in the Mediterranean basin
MPAS: Model Prediction Across Scales.

Earth-system component models collectively known as MPAS:

MPAS-Ocean (LANL)

MPAS-Atmosphere (NCAR)

MPAS-Land/Sea Ice (Albany U, LANL,..)

All MPAS components use centroidal Voronoi tessellations for their horizontal meshes.

Common software framework between components and partially with WRF
DYNAMICS

Non-hydrostatic

Horizontal velocity is defined as the normal velocity on Voronoi cell faces.

State variables are defined at the cell centers.

For the vertical coordinate a structured grid is assumed, the model can use traditional sigma coordinates as well as a Hybrid Coordinate system as in last versions of WRF.

PHYSICS

Surface Layer: Monin-Obukhov as in WRF 3.8.1, MYNN as in WRF 3.6.1.

PBL: YSU as in WRF 3.8.1, MYNN as in WRF 3.6.1.

LSM: Noah as in WRF 3.3.1.

Gravity Wave Drag: YSU GWDO as in WRF 3.6.1.

Convection: Kain-Fritsch as in WRF 3.2.1, Tiedtke as in WRF 3.3.1, New Tiedtke as in WRF (3.8.1), Grell-Freitas as in WRF 3.6.1.

Microphysics: WSM6 as in WRF 3.8.1, Thompson as in WRF 3.8.1, Kessler

Radiation: RRTMG sw as in WRF 3.8.1, RRTMG lw as in WRF 3.8.1, CAM as in WRF 3.3.1-3.5

MESHES

Global model version.

Quasi-uniform and variable resolution grids
Applications

**WRF**
- Urban meteorology
- LES modeling
- Obs/grid nudging applications
- Fire model coupling
- Regional NWP
- Tropical cyclone/hurricane prediction
- Convection permitting hazardous forecasting
- Regional atmospheric chemistry
- Ensemble (EnKf), variational and Hybrid DA
- Idealized simulations across scales
- Regional air quality

**MPAS**
- Global NWP
- Integrated global/regional NWP
- Global atmospheric chemistry
- Global/regional climate modeling
- Seasonal prediction

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MPAS-A: A first view in the Mediterranean basin
MPAS-A: Strengths and Weaknesses

**BENEFITS**

All scales are solved at the same time.

Common physical packages with WRF (NCAR Unified Atmosphere Modeling Roadmap).

Scaling improvement.

**LIMITATIONS**

High memory consumption

Quasi-uniform mesh at 60 km: 163.842 cells
Variable resolution grid 92-25 km: 163.842 cells

~30 GB

Variable resolution grid 60-10 km: 999.426 cells
Variable resolution grid 15-3 km: 6.488.066 cells
Experiments

Reanalysis: ERA-5

Initialization: 2015-12-10 18:00 h

Spin-up: 6 hours

Effective horizon: 24 hours

Output: hourly

LBC: updated every hour

WRF 3.6.1

Domain: 120x120 = 14,400 cells x 38 levels

Resolution: 60 km

Physics:

- SW: RRTMG
- LW: RRTMG
- Sfc layer: ETA-Similarity
- LSM: 5-layer thermal diffusion
- PBL: YSU
- Cumulus: Kain-Fritsch
- Microphysics: WSM6
Experiments

Reanalysis: ERA-5
Initialization: 2015-12-10 18:00 h
Spin-up: 6 hours

Effective horizon: 24 hours
Output: hourly
LBC: none (global model)

MPAS-A 6.0

Domain: 163,842 cells x 38 levels (global)
Resolution: 60-km quasi-uniform mesh

Physics:

SW: RRTMG
LW: RRTMG
Sfc layer: ETA-Similarity
LSM: 5-layer thermal diffusion
PBL: YSU
Cumulus: Kain-Fritsch
Microphysics: WSM6
Experiments

**Reanalysis:** ERA-5

**Initialization:** 2015-12-10 18:00 h

**Spin-up:** 6 hours

**Effective horizon:** 24 hours

**Output:** hourly

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**MPAS-A 6.0**

**WRF 3.6.1**

Regridding

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Results: 2-meter temperature

WRF 4:00 UTC

MPAS 4:00 UTC

WRF-MPAS 4:00 UTC

WRF 7:00 UTC

MPAS 7:00 UTC

WRF-MPAS 7:00 UTC

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MPAS-A: A first view in the Mediterranean basin
Results: 2-meter temperature
Results: 2-meter temperature

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MPAS-A: A first view in the Mediterranean basin
Results: 2-meter water vapor mixing ratio
Next steps

Tests with variable resolution meshes

Full validation:
- Long period
- Different regions
- 3D fields
- Model options
- Explore applications
- New products

Regional MPAS with LBC (expected 2019)
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