The development of a WRF-RTFDDA-based high-resolution hybrid data-assimilation and forecasting system for the Eastern Mediterranean

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Motivation: NWP challenges

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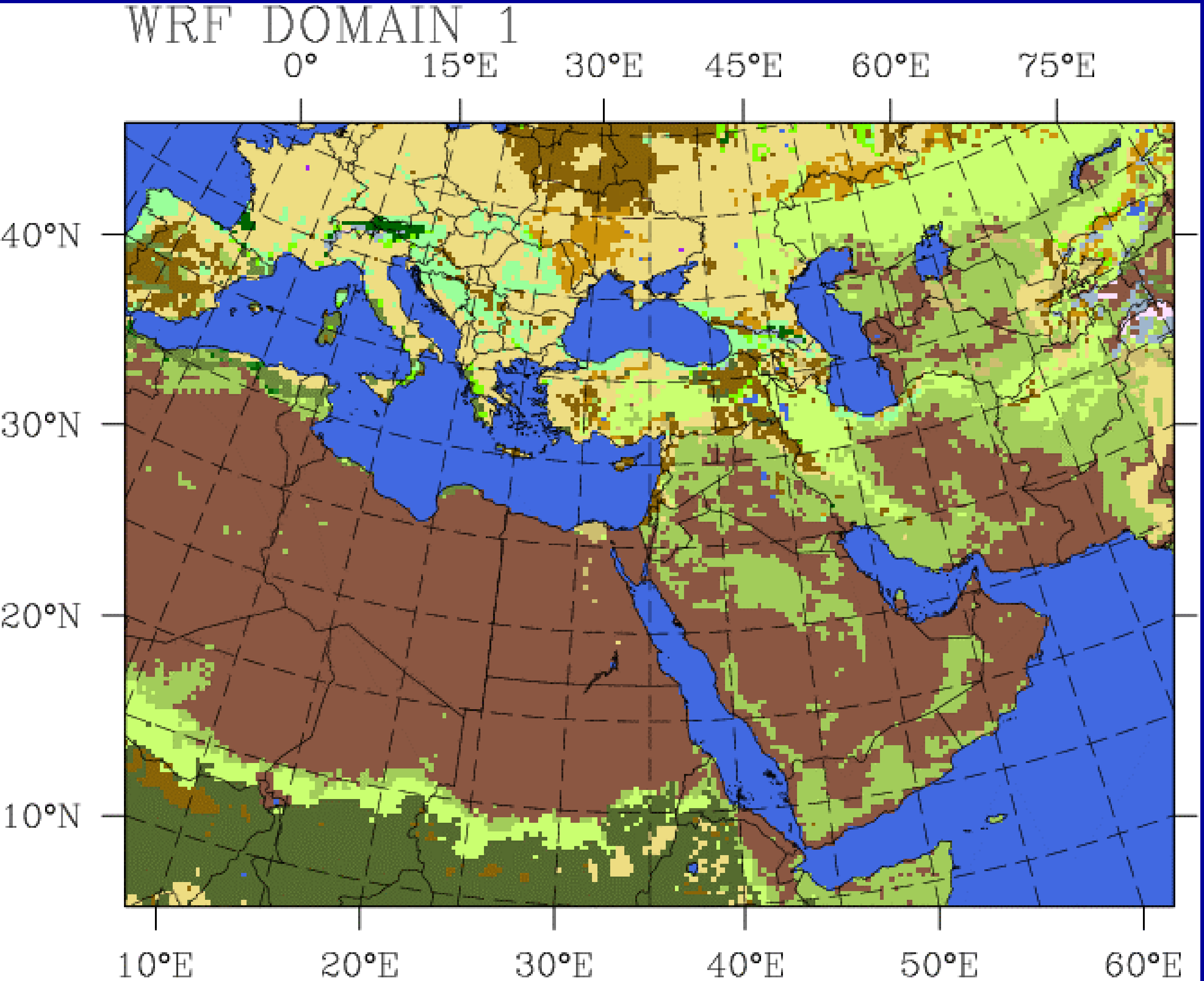
- **Region's unique geography:** strong land-sea contrast, complex topography, varied vegetation, and mosaic of urban and desert areas.

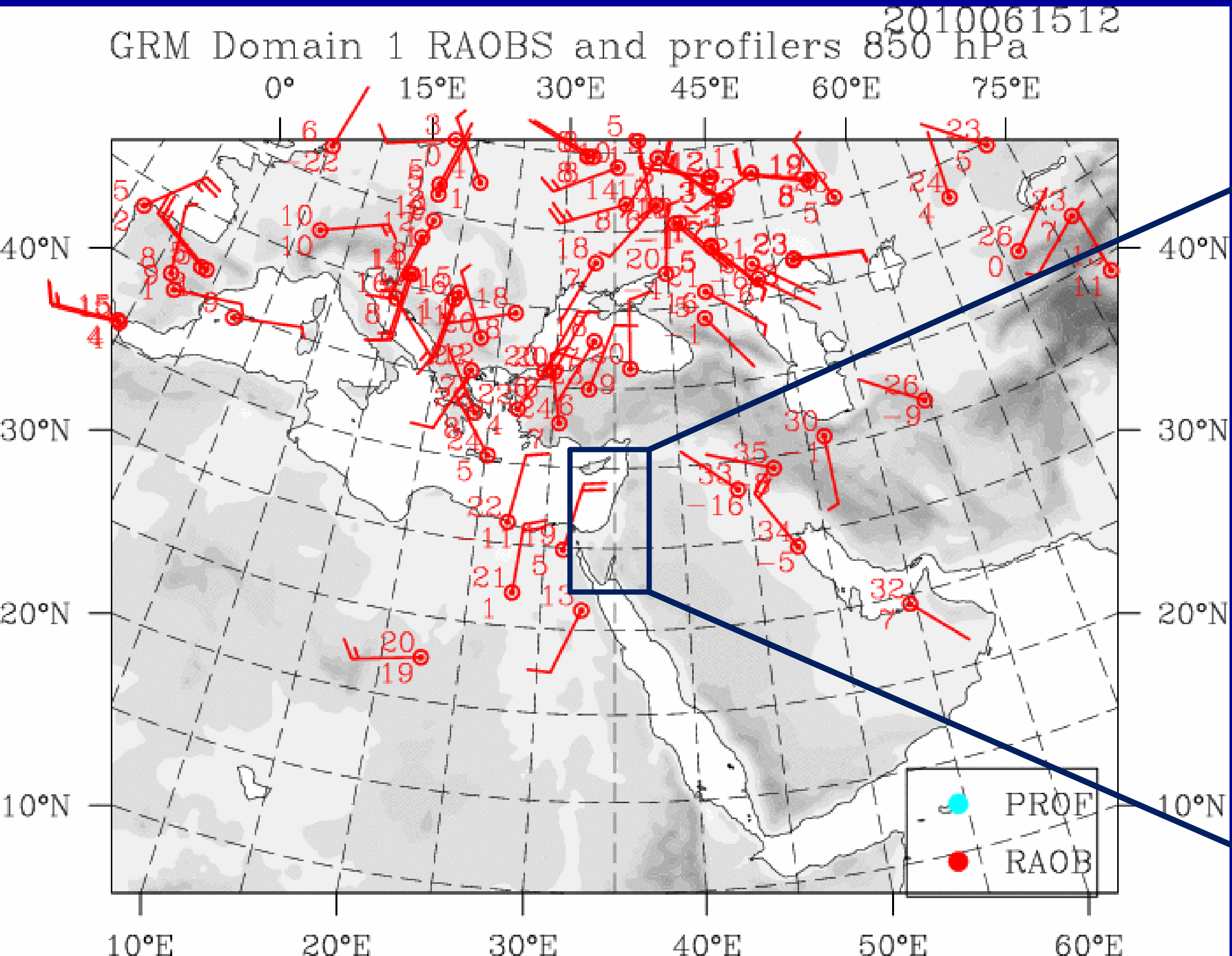


This geographic characteristics results in complex mesoscale and microscale flows that are forced by a wide variety of synoptic scenarios.

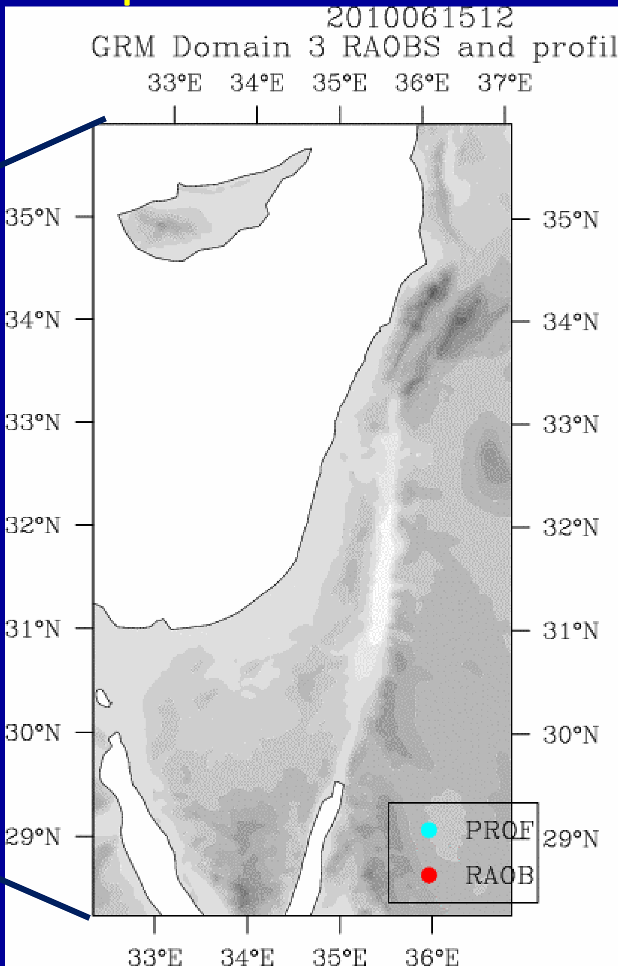
NWP challenges, continued

- **Observations availability:** Upper air and surface in-situ observations are sparse over sea and several land areas.

Soundings snapshot



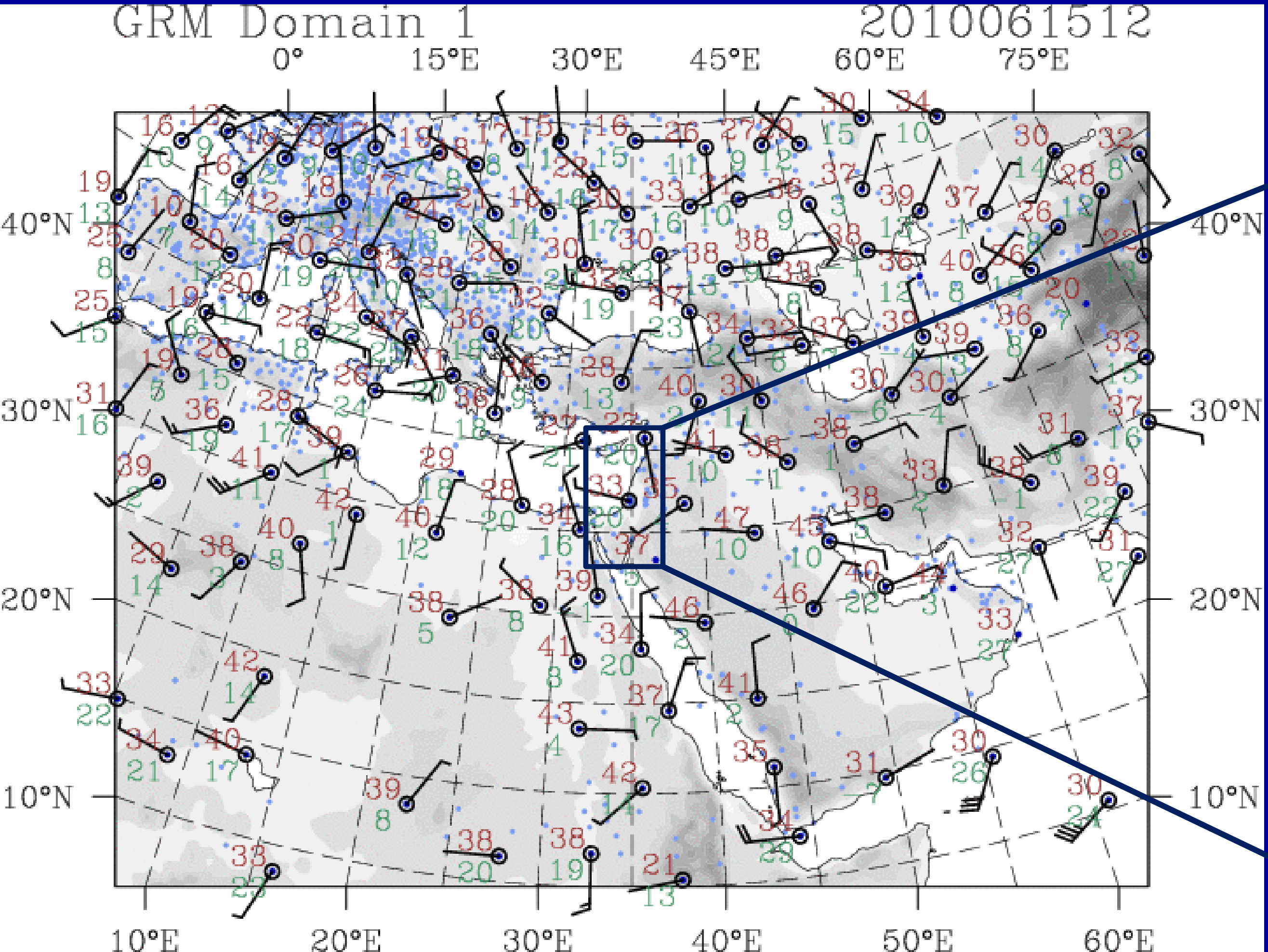
Soundings snapshot over Levant



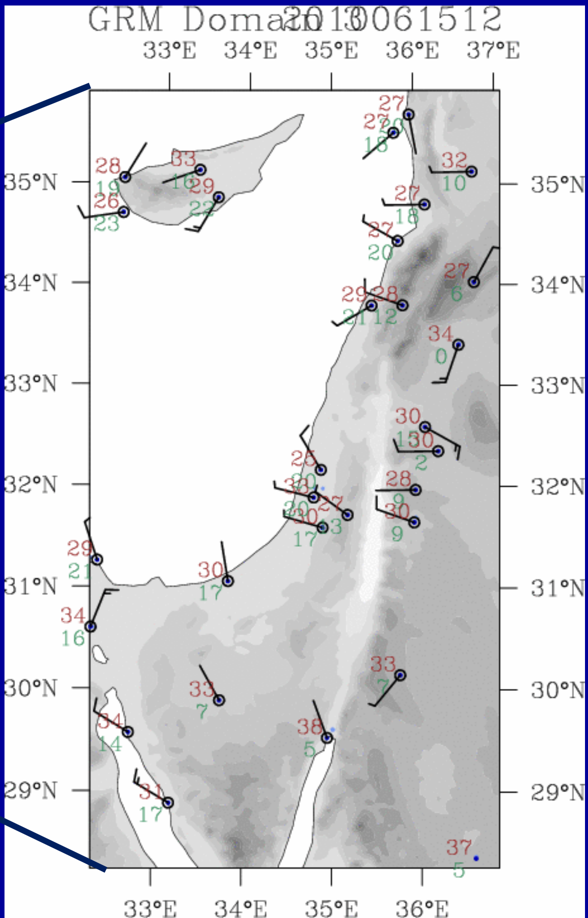
NWP challenges, continued

Surface observation are abundant at certain areas

Surface-observations snapshot



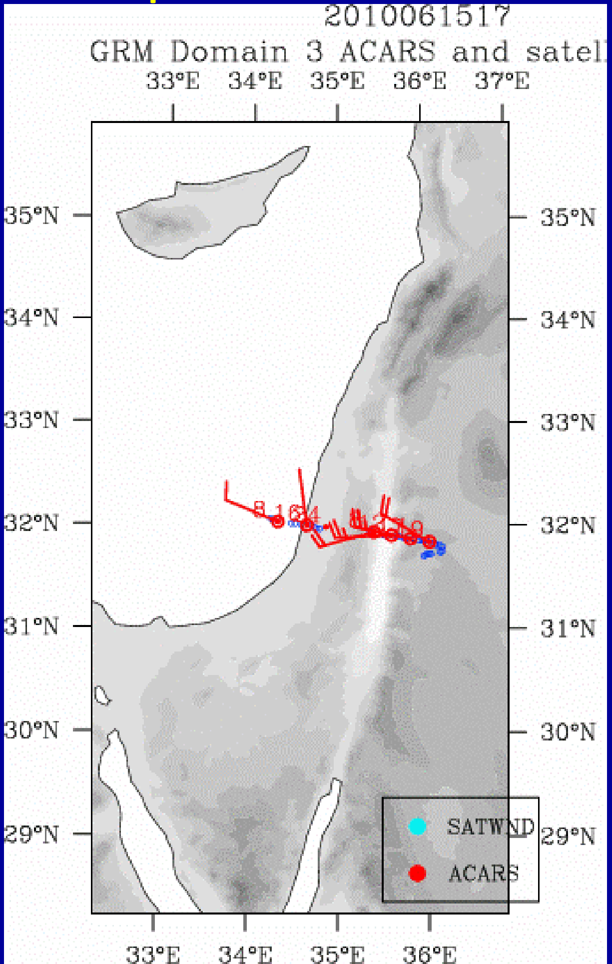
Surface-observations snapshot over Levant



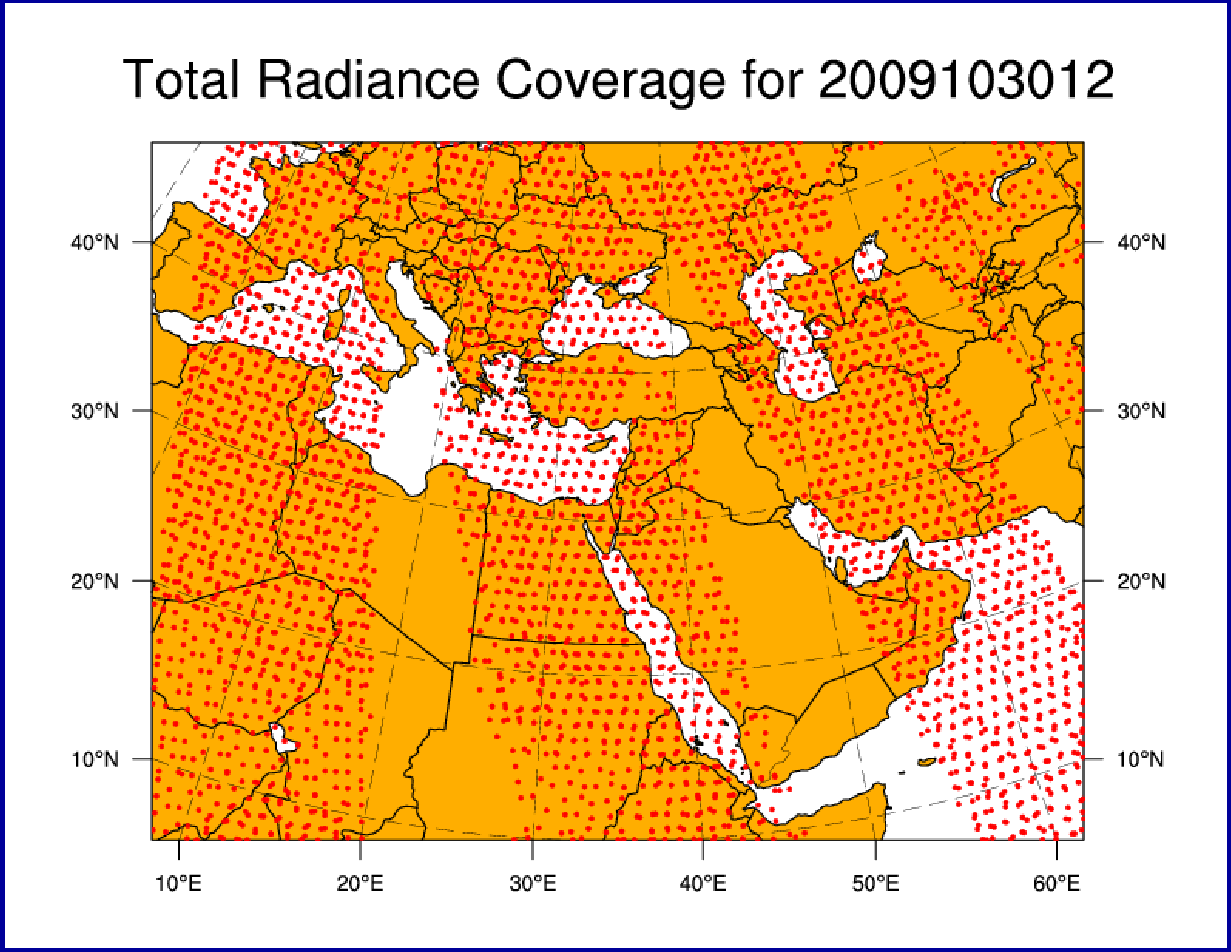
NWP challenges, continued

- Several non-conventional observations may fill the observational gap:

ACARS and Sat-winds snapshot over Levant



AMSU-AB, MHS snapshot



Modeling approach

Modeling approach:

- **Multiple-nested domains:** Proper resolution of synoptic, meso-beta, and gamma scales optimally using computing resources.

- **Data-assimilation (DA) system**: capable of efficiently assimilating all **conventional** observations and **remote-sensing** measurements. (**talk 3A.10**)

- **Optimal model configuration through case studies:** evaluation of combinations of physical-parameterization schemes, lateral-boundary condition specifications, and numerical and DA parameters for regional prevailing and high-interest weather scenarios.

  (**talk 4.9, poster P.64**) .

- **Thorough verification against point, satellite and radar observations:**
  - Of case studies in details
  - Accumulated verification statistics of real-time runs.

Modeling approach implementation

Modeling implementation

- 3 WRF nested domains (30, 10 and 3.3 km grid-size).
- Data assimilation strategy: Computationally-cheap hybrid built upon:
  - WRF obs-nudging: NCAR/RAL's WRF-RTFDDA
    - Most advantageous at **fine spatial and temporal resolution.**
    - Assimilates **prognostic variables only** (sparsely distributed).
    - Continuous cycling, all nested-domains.
  - WRF-3DVar:
    - Assimilates also **observations that are not model prognostic variables** – e.g. microwave radiances (AMSU-A,B, MHS).
    - Most favorable at **relatively coarse spatial and temporal resolution.**
  - WRF grid (spectral)-nudging: Grid-nudge obs-nudging analysis to 3DVar analysis.

Snapshots of selected sensitivity tests

Improve the coarse resolution prediction

Sensitivity to AMSU-A,B, MHS assimilation with WRF-3DVar

(many thanks to Craig Schwartz)

Sensitivity to AMSU-A,B,MHS assimilation with WRF-3DVar

Radiances assimilation proven useful with global models, still challenging with regional models.

Configuration:

- Time period: 1200 UTC 24 Oct through 1200 UTC 31 Oct 2009, inclusive.
- Domain: 30-km grid-size.
- Three-hourly full-cycling (previous 3-hr forecast used as “first-guess” field)
- Conventional observations assimilated every three hours to produce new analysis
- Radiances (when used) assimilated every 6 hours
- CV5 Background Error used, generated specifically for the 30-km grid-size domain.

details

Sensitivity to AMSU-A,B,MHS assimilation with WRF-3DVar

- Three experiments to examine sensitivity of radiance DA:

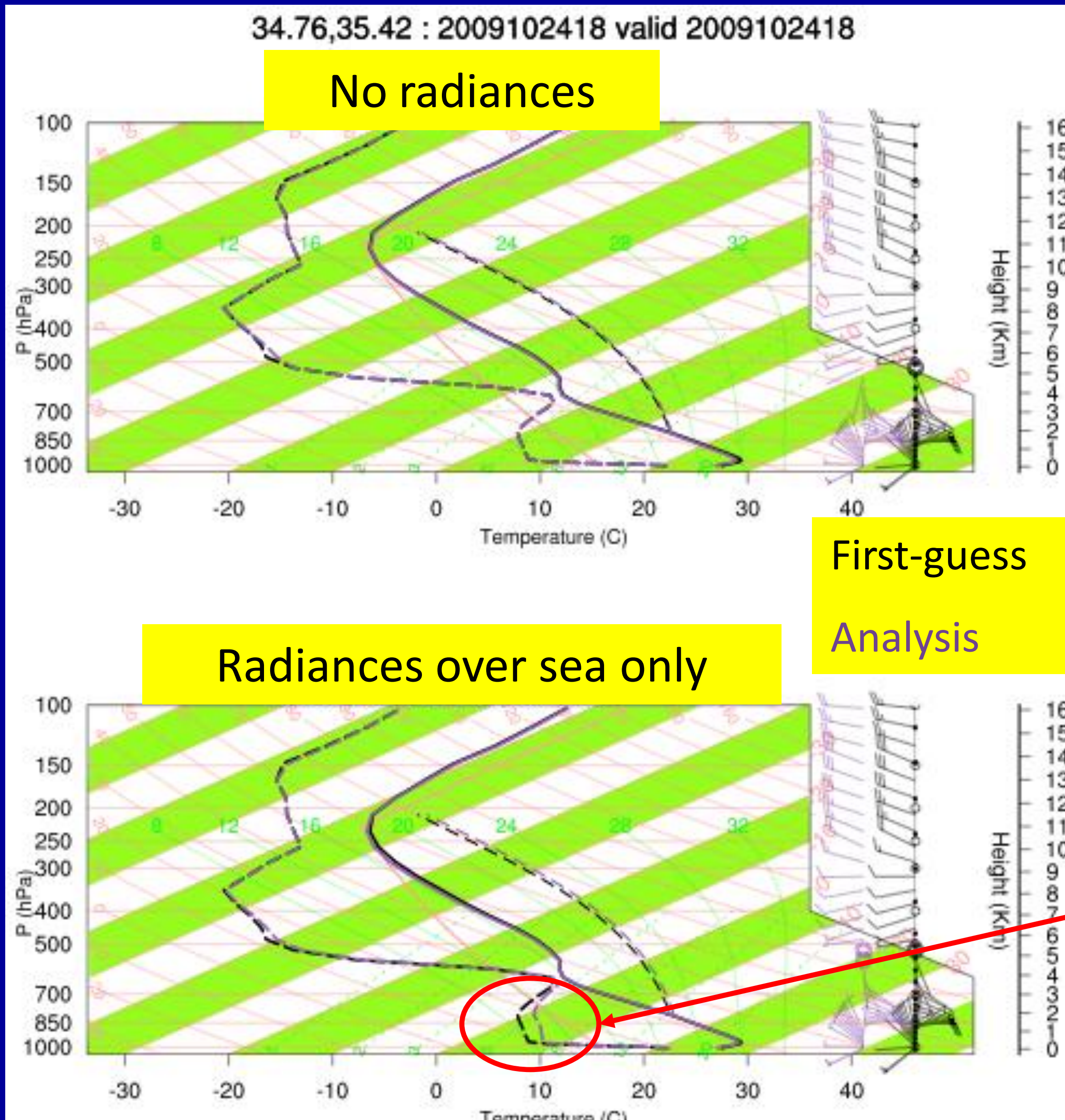
  1) Assimilated conventional observations ***only***

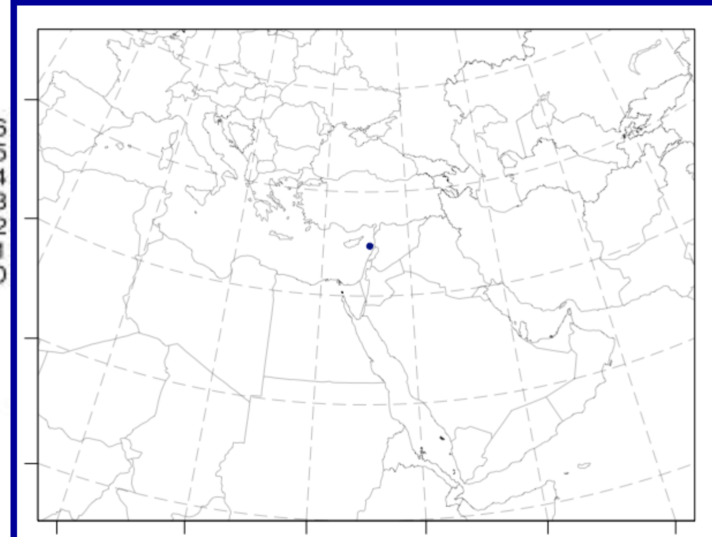
  2) Assimilated conventional observations and AMSU-A,B, MHS radiances over land and sea

  3) Assimilated conventional observations and AMSU-A,B, MHS radiances over sea only

  (weather of interest develops over the sea, e.g. extratropical cyclones, radiative transfer models more accurate over the sea)

Point Soundings over the sea

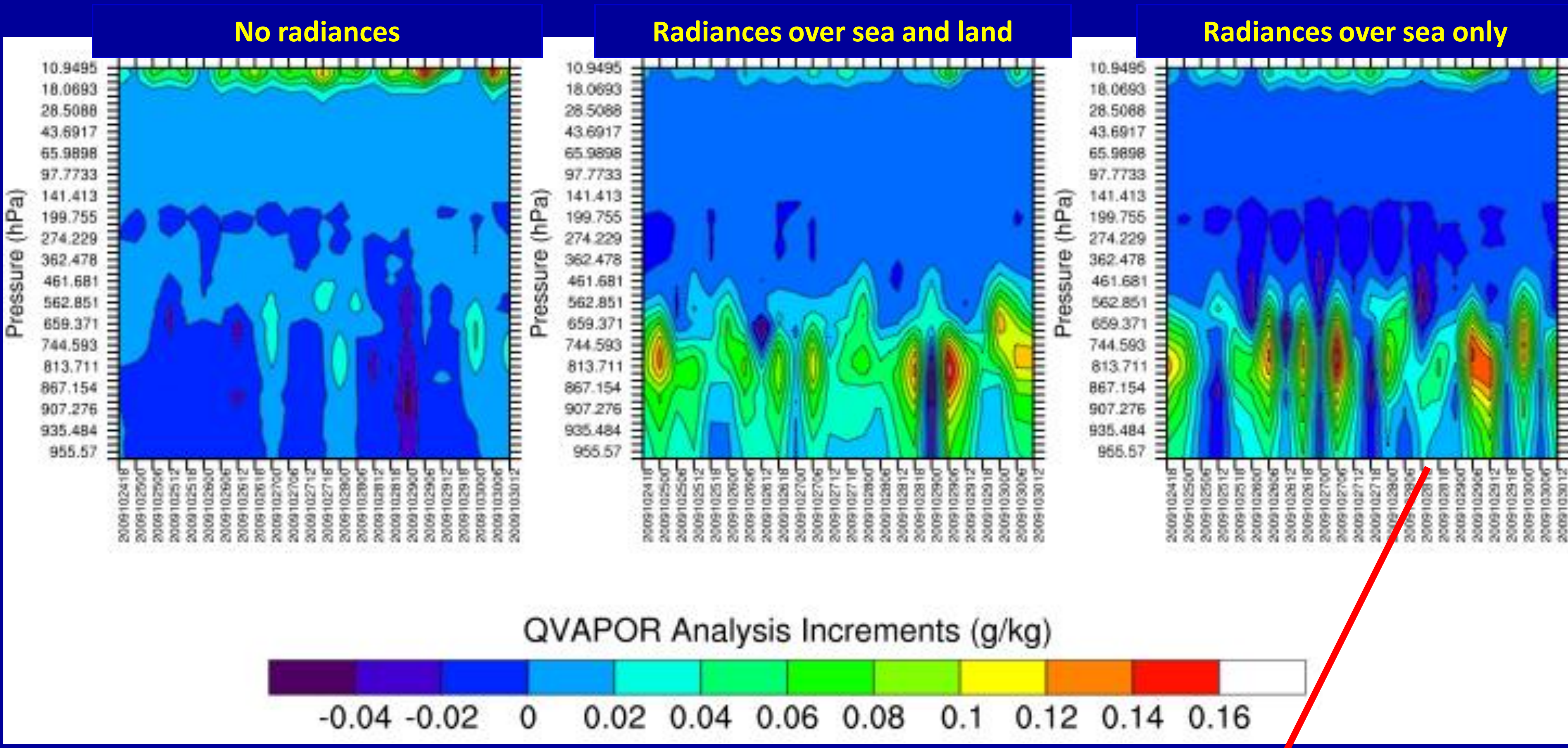




Slight moistening…occurred at many locations, at levels where AMSU-B has significant power.

Mean Analysis Increments

- Calculated <u>only</u> at grid-points where radiances were assimilated



Mid-level (~850-500 hPa) moist tendency

- **Is it good**? Verification over sea is challenging…very few soundings….
- Find accurate analyses or retrieved profiles (GPS RO?), verify secondary effects (precipitation), verify over land…

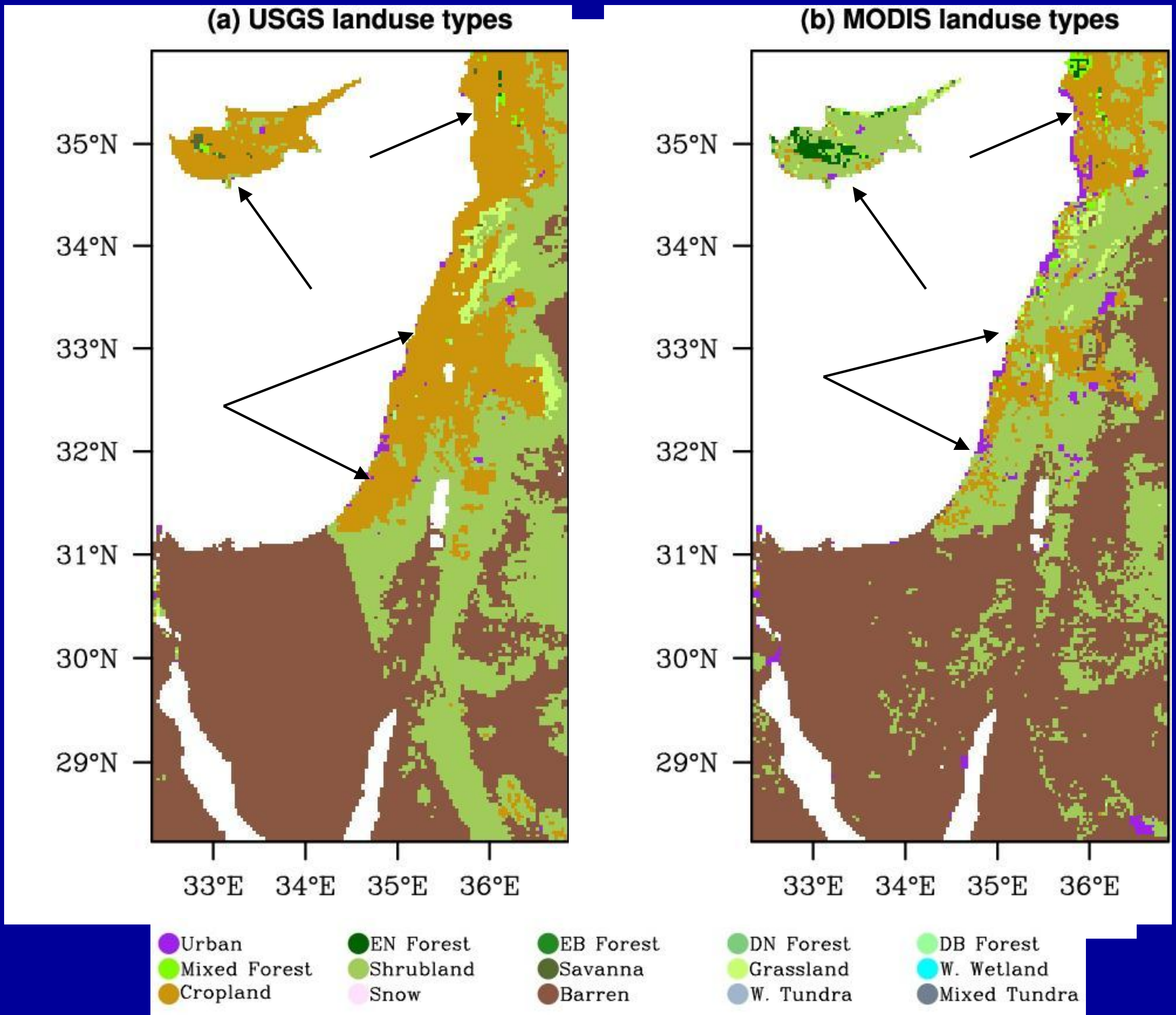
Improve the fine scale prediction

Sensitivity to Land Cover Data Set

(many thanks to Yongxin Zhang)

Sensitivity to Land Cover Data Set

USGS (older) vs. MODIS (newer) Land Data



(Nested domain, 3.3-km grid-size)

USGS->MODIS

Increases:

1. Urban
2. Forest
3. Barren

Decreases:

1. Cropland
2. Shrubland

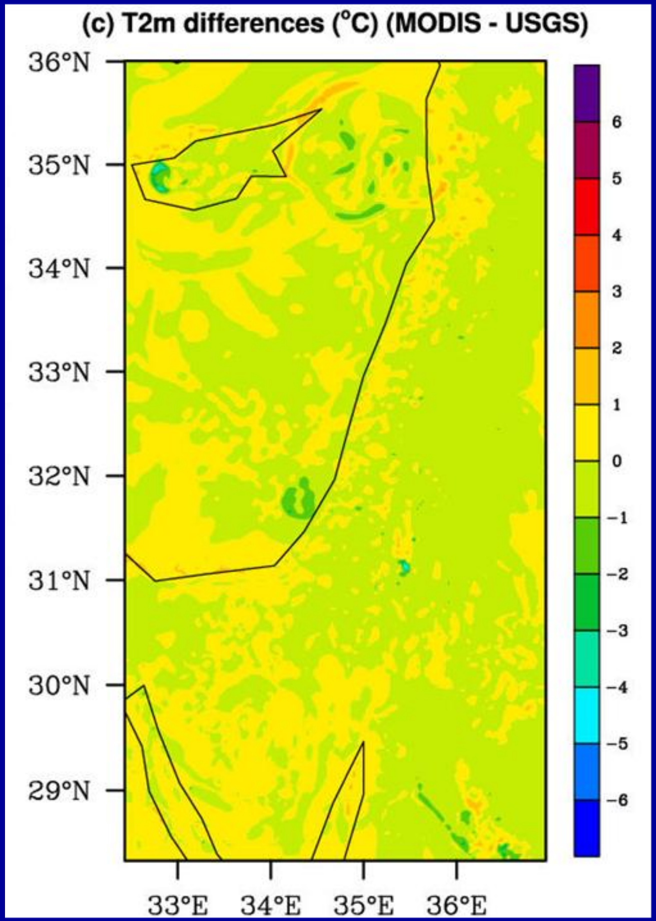
Case study

- Period: 10/22/2008 to 10/25/2008.
- Synoptic: An upper-level trough passed by the Eastern Mediterranean region during the period and brought in appreciable rainfall
- **This case represents strong synoptic forcing**

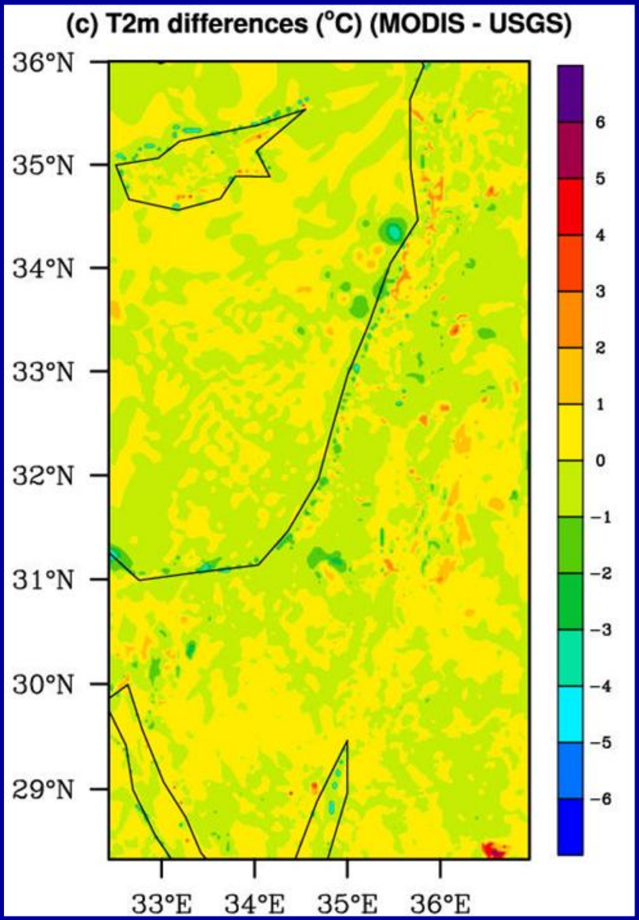
WRF options

WRF simulated 2-m temperature differences (MODIS-USGS)

13:00 LST



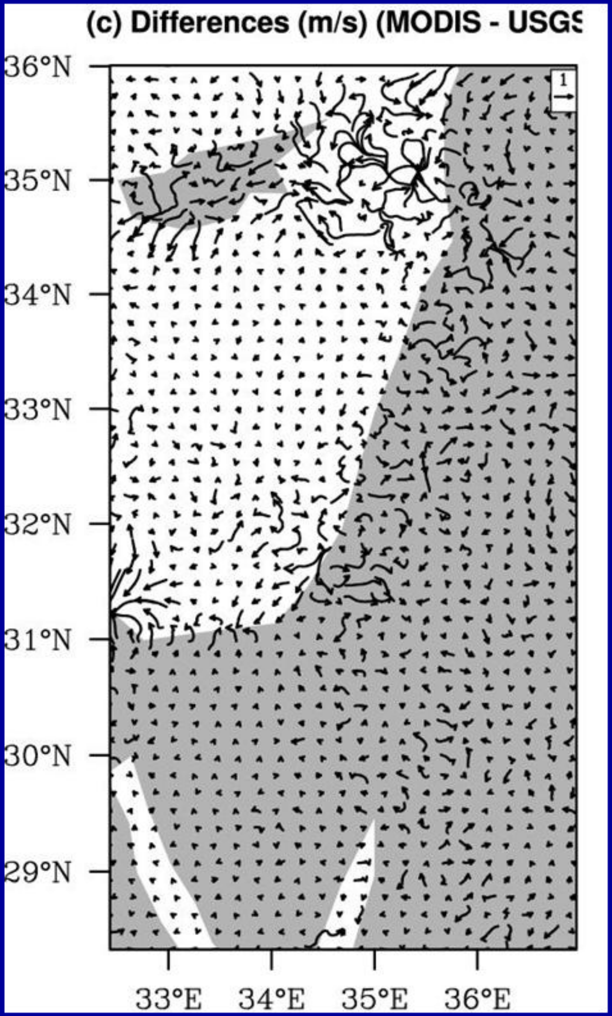
05:00 LST



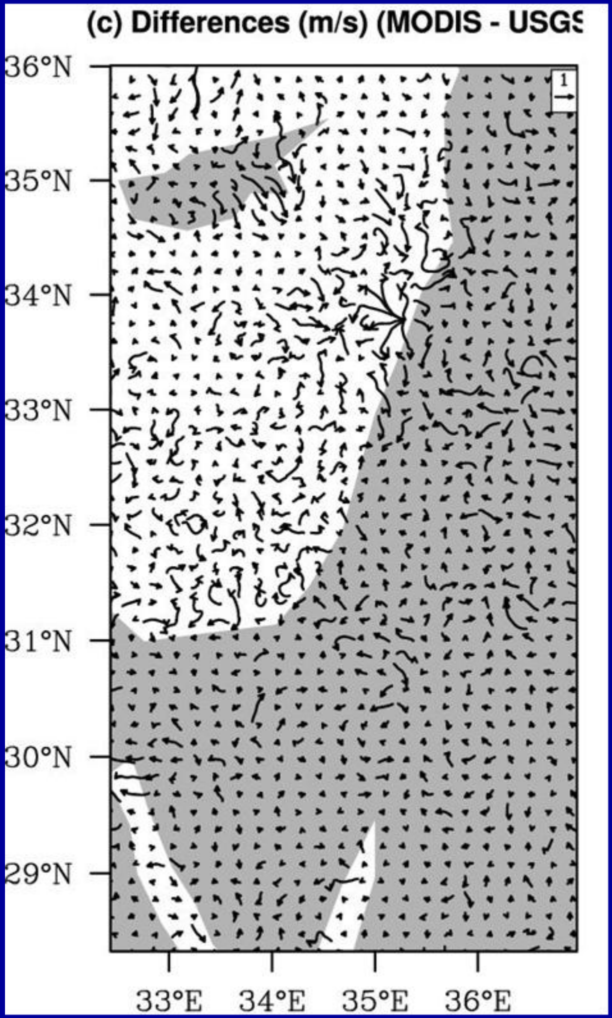
•Differences more significant when radiative cooling takes place (05:00 LST), in particular **urban (MODIS, warmer) vs. rural (USGS, colder).**

WRF simulated 10-m winds differences (MODIS-USGS)

13:00 LST



05:00 LST



Differences in 10-m winds even under strong-synoptic flow.

Summary

- We presented a strategy to develop a NWP system optimized for the Eastern Mediterranean.

- Some sensitivity tests were presented. These are intended to improve the coarse and fine scale flow prediction.

- Research continues. See you next year.

Thanks

To all the scientists, engineers, forecasters and managers that push this research forward.

WRF options

Physics	Scheme
Nested-grid	One-way
Time Integration	Fixed time step
Land-Surface	NOAH
Surface Layer	Monin-Obukhov
PBL	YSU (non-local mixing)
Shortwave Radiation	Dudhia
Longwave Radiation	RRTM
Cloud Microphysics	Lin et al
Cumulus scheme	Kain-Fritsch (30 & 10km)

Model Top: 10 hPa; 57 vertical levels

Radiances assimilation details

- Variational bias-correction.
- 90-km thinning.
- CRTM radiative transfer model.
- Non-precipitating skies only.
- Model top at 10 hPa.